III. ENVIRONMENTAL IMPACT

A. INTRODUCTION

In this section is described the environmental impact of waste discharges from INEL facilities; routine discharges and postulated accidental releases are evaluated. The magnitude of the impact on man is limited because of the relative isolation of INEL facilities and the low population density in the surrounding area.

The only major areas of industrial development that could have any significant environmental interplay with INEL lie to the east and southeast of INEL. Electrical energy to these areas (including INEL) is provided by hydroelectric and fossil-fueled generating stations. Light manufacturing, food processing, and phosphate ore processing release particulate material and other industrial wastes from these industrial areas into the environment. The prevailing winds (from the southwest) generally transport these effluents away from INEL; consequently, their release has not increased the mass concentration of suspended particulate material at onsite monitoring locations. It is therefore not likely that cumulative or synergistic impact on the environment off INEL will be produced as the result of INEL industrial waste discharges.

There are no nearby nuclear facilities which contribute to the environmental radioactivity levels around INEL, so the INEL facilities represent the only industrial sources of manmade radioactivity to which the local environment and its inhabitants are exposed.

The impact of INEL releases of radioactivity is superimposed upon that of existing natural (background) radioactivity and that of variable environmental radioactivity levels resulting from nuclear weapons testing at the Nevada Test Site and elsewhere in the world. The natural radioecology background of the region is affected by phosphate mining and processing in the area.

The analyses of radiological impacts presented here consider both the direct and indirect routes by which released radioactivity is transported to man. The importance of each exposure route depends upon many factors including the chemical and biological behavior of the radioactive material, the distance to agricultural areas, agricultural management procedures, recreation use patterns around the facility, and local meteorology and hydrology.

Figure III-1 illustrates potential exposure pathways to man for airborne radioactive effluents released from INEL facilities. The direct exposure routes (inhalation of radionuclides and radiation from the cloud) are most important for released noble gases and tritium, because their transfer to soil and plant surfaces and concentration in plants or animals are not significant pathways. Particulate material and reactive gases such as elemental iodine can be transferred to

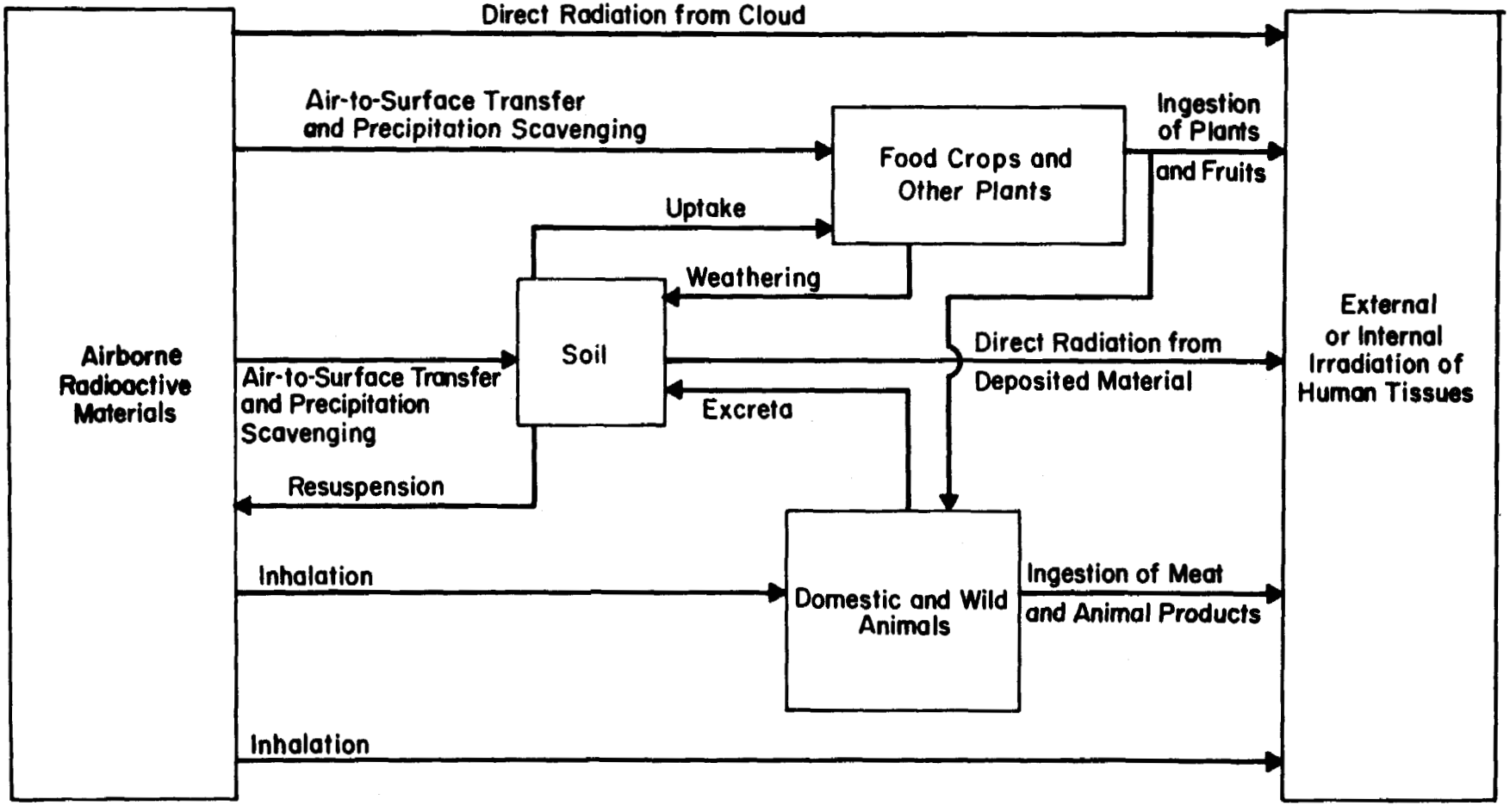

Figure III-1. Potential Exposure Pathways for Radionuclides Released to the Atmosphere.

plants and to soil, and then to domestic and wild animals which consume the vegetation. No food crops are produced on INEL land; those produced offsite are grown in uncontaminated soil. Direct radiation from radioactivity which has accumulated in soil on INEL may result in slightly increased doses to herdsmen whose flocks graze onsite. Animals foraging onsite will consume greater amounts of radionuclides than those grazing offsite. The magnitudes of the doses resulting from these pathways are evaluated in detail in Section III.B.

Figure III-2 illustrates potential exposure pathways to man for radioactive liquids discharged from INEL facilities to surface ponds and to the Snake River Plain aquifer. Direct radiation from surface ponds and pond bottoms is not included because the ponds are in a restricted area. Consumption of crops grown in soil around the ponds is a possible pathway only if the lands are ever released for public use. Contamination of pumped water supplies has not been observed at offsite locations; however, transport of very low levels of tritium beyond the southern INEL boundary is projected by the year 2000. The principal existing offsite exposure pathway to individuals is the consumption of wild species which have consumed contaminated water and plants around the disposal ponds. Since hunting is not permitted on INEL land, the contaminated species must move from pond locations to offsite areas before entering man's food supply.

Figure III-3 illustrates potential exposure pathways involving radioactive solid waste stored or buried at INEL. Solid waste storage and burial areas, like the surface disposal ponds, are under ERDA control and public access is not permitted. Consequently, direct radiation from solid waste containers is not considered a potential pathway, and the possibility of food crop contamination due to this solid waste entails a future decision to make the land available for farming. The low annual rainfall and the presence of sedimentary layers between the basalt beds, which provide a barrier at least 200 ft thick below the waste burial and storage areas, make the probability of the aquifer becoming contaminated very small. Resuspension of surface contamination is the only pathway identified as significant for present land management practices.

The significance of the various potential exposure routes will be considered further in the following paragraphs which also contain data on INEL effluent releases and environmental concentrations. The release data and environmental impact on land and water and on the human population for the most recent complete year of record (1974) are presented in detail.

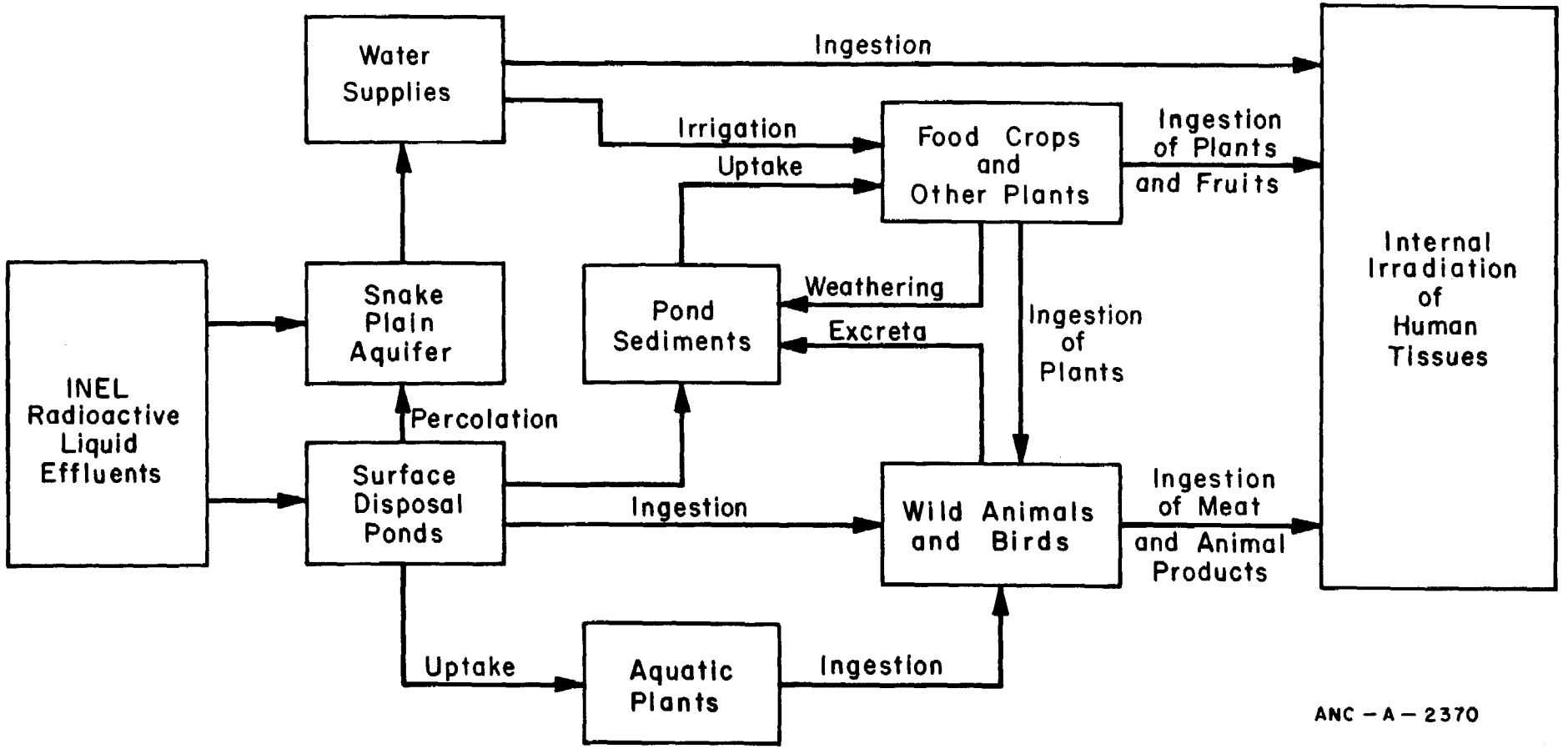

Figure III-2. Potential Exposure Pathways for INEL Radioactive Liquid Effluents.

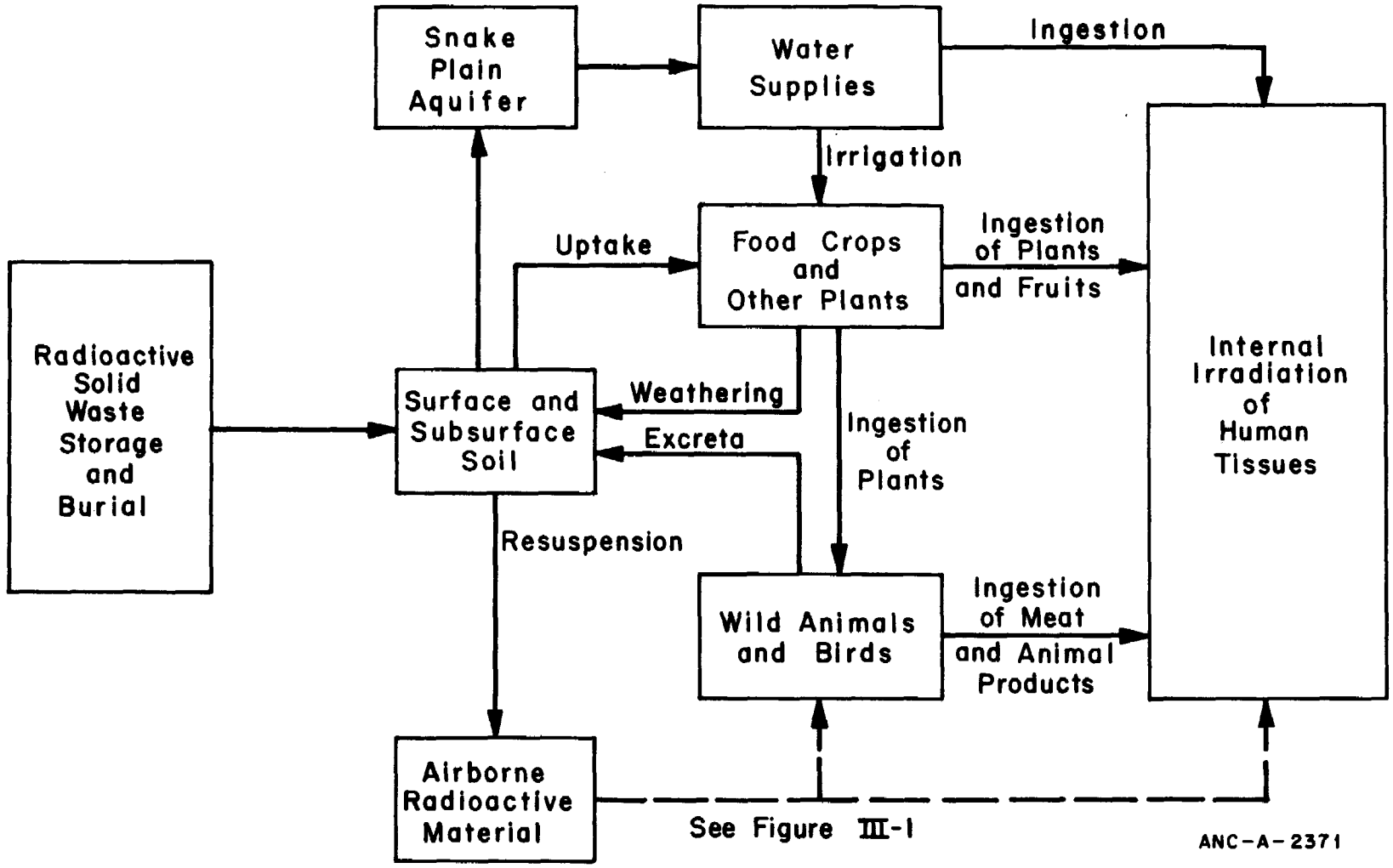

Figure III-3. Potential Exposure Pathways for Radioactivity in Solid Wastes.

B. ENVIRONMENTAL IMPACT OF ROUTINE OPERATIONS

The following section describes the radioactive and industrial airborne and liquid waste discharges from routine operations and their impact on the environment and man. Radioactive and nonradioactive solid wastes buried or stored at INEL are then discussed and their impact analyzed. The impact of waste heat discharges to the INEL environment is also discussed. The concluding section discusses maximum health effects from ionizing radiation and compares these effects to doses from radioactivity released to the environment from INEL facilities.

1. Radioactive Airborne Waste Discharges to the Atmosphere[a]

a. Sources of Discharges

The discharge of radioactivity to the atmosphere from stacks is the largest local source of manmade radionuclides found in the onsite or offsite environs. These releases are continually monitored at the source and in the environs. The policy has always been to maintain releases as low as practicable and below the standards given in AEC(ERDA) Manual Chapter 0524[7]. During the last several years, programmatic changes, management controls, and improvements in airborne waste systems have reduced the quantity of radioactive contaminants released. Table III-1 is a summary of the airborne releases since 1952. Figure III-4 is a graphical representation of the yearly releases. The higher releases during the 1959 to 1963 period were caused by special processing operations at ICPP which contributed short-lived nuclides (see RaLa processing in Section II.C.11). Higher releases during 1974 resulted from a combination of reprocessing higher burnup fuel and an increased reprocessing period. (Projection of waste discharges in the near future is summarized in the Foreword).

During 1974, a total of 287,500 Ci was released from INEL facilities to the atmosphere. The isotopic composition of these releases is shown in Table III-2. The noble gases (argon, krypton, and xenon) comprise 98% of the total activity released. Krypton-85 contributes 253,900 Ci; krypton-88, 3,644 Ci; argon-41, 4,128 Ci; and xenon-138, 6,432 Ci. Tritium releases totaled 6,037 Ci or about 2% of the released activity. Particulate activity was less than 1% of the total released. These quantities are graphically shown in Figure III-5.

The major source of argon-41 has been the TRA reactors which have released over 96% of the total. The reactors at EBR-II have released the remaining 4%. Essentially all of the airborne tritium and krypton-85 is discharged from ICPP. The minor releases of radionuclides from other facilities are shown in Table III-2. More than 99% of the atmospheric releases occur at TRA and ICPP. Only minor releases

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[a] See Appendix E (Table E-1 and Section 2) for 1975-76 airborne releases and their environmental impact.

TABLE III-1

SUMMARY OF RADIOACTIVITY RELEASED TO THE ATMOSPHERE -- 1952-74

Year	Radioactivity Released in Curies					
	TRA[a]	ICPP[b]	TAN[c]	ANL[d]	Others[e]	Total
1952	168,000	---	---	---	---	168,000
1953	370,000	14,900	---	---	---	384,500
1954	272,000	37,100	---	---	---	308,600
1955	404,000	52,200	---	---	---	456,200
1956	198,000	83,000	---	---	50	281,200
1957	76,400	591,600	---	---	50	667,900
1958	104,000	1,057,800	20,000	4,560	<7	1,186,000
1959	169,000	1,275,000	11,100	---	164	1,455,000
1960	232,000	829,700	20,100	176	1,620	1,082,400
1961	335,000	1,155,800	2,520	106	85	1,493,800
1962	349,000	630,485	---	186	600	980,271
1963	597,000	365,400	<1	206	<1	964,300
1964	569,300	84,660	<1	7,937	3	661,900
1965	520,600	46,400	<1	18,800	65	585,865
1966	334,200	53,470	<1	4,200	3	391,873
1967	197,800	21,150	<1	2,760	<1	221,710
1968	126,200	86,070	<1	837	505	213,612
1969	65,510	111,400	<1	130	<1	177,040
1970	34,810	148,100	<1	84	<1	182,994
1971	18,870	136,600	<1	74	<1	155,500
1972	10,380	45,890	<1	127	<1	56,400
1973	11,510	4,823	<1	803	<1	17,140
1974	26,960	260,000	<1	666	2	287,500

[a] TRA area includes the ATR, ETR, and MTR. ETR operations started in 1957 and ATR in April of 1969. MTR operations ceased in 1970.

[b] Special fuel processing (RaLa) was conducted during the period 1957 to 1963 at ICPP and accounts for the relatively large releases.

[c] Releases during 1957 through 1961 are attributed to ANP operations.

[d] Includes EBR-I, EBR-II, TREAT, and HFEF.

[e] Includes NRF; GCRE; OMRE; SPERT-I, -II, -III, and -IV; and SL-1.

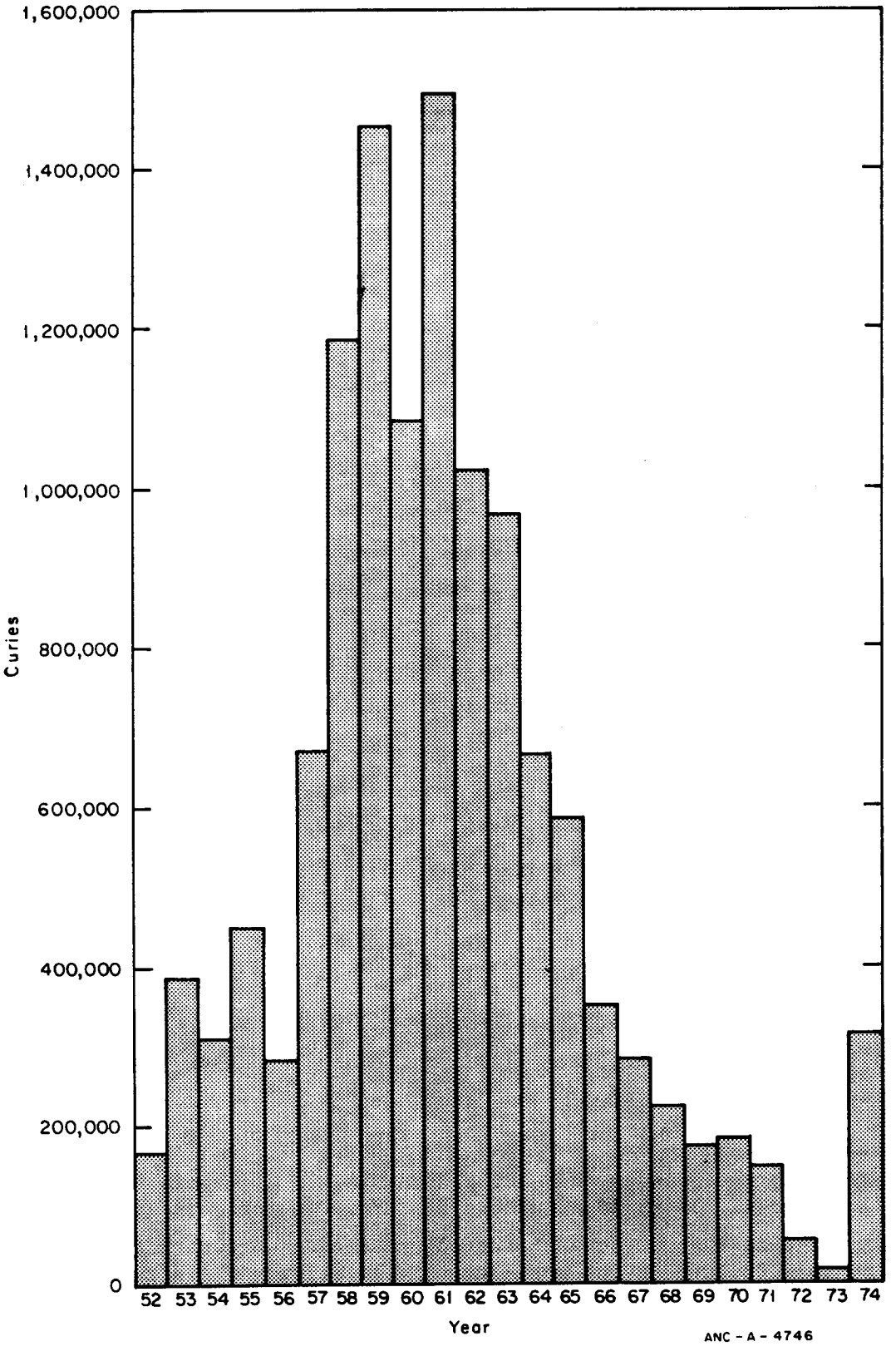


Figure III-4. Graphical Presentation of Radioactivity Release to the Atmosphere (1952 to 1974).

TABLE III-2

AIRBORNE NUCLIDE SUMMARY IN CURIES FOR 1974

Nuclide	Half-Life	ANL	CFA	ICPP	NRF	PBF	TAN	TRA	Total
Antimony-125	2.7 yr			6.3					6.3
Argon-41	1.8 hr	1.48 (2)			1.1 (-4)			3.98 (3)	4.13 (3)
Barium-139	83 min							5.1 (2)	5.1 (2)
Bromine-82	35 hr	6.7 (-2)							6.7 (-2)
Cerium-144	282 days			6.8 (-1)					6.8 (-1)
Cobalt-60	5.3 yr			3.4 (-3)			1.2 (-6)		3.4 (-3)
Cesium-134	2.3 yr			5.5 (-1)			5.2 (-7)		5.5 (-1)
Cesium-137	30 yr			6.7			8.4 (-5)		6.7
Cesium-138	32 min							4.4 (1)	4.4 (1)
Europium-154	16 yr			2.4 (-2)					2.4 (-2)
Europium-155	1.8 yr			8.4 (-4)					8.4 (-4)
Fluorine-18	110 min [a]				1.9 (-4)				1.9 (-4)
Iodine-129	1.56 (7)			1.0 (-1)					1.0 (-1)
Iodine-131	8 days	1.1 (-1)			6.2 (-5)				1.1 (-1)
Krypton-85	10.8 yr	1.4 (-1)		2.54 (5)	2.1				2.54 (5)
Krypton-85m	4.4 hr							1.3 (3)	1.3 (3)
Krypton-87	76 min	6.2 (-1)						4.2 (3)	4.2 (3)
Krypton-88	2.8 hr	3.7 (-1)						3.6 (3)	3.6 (3)
Krypton-89	3.2 min							5.5 (2)	5.5 (2)
Manganese-54	312 days			4.95 (-3)					4.95 (-3)
Nitrogen-13	10 min				5.6 (-4)				5.6 (-4)
Niobium-95	35 days			8.0 (-3)					8.0 (-3)
Plutonium-238	89 yrs			4.1 (-3)					4.1 (-3)
Plutonium-239	2.43 (4) yrs			3.0 (-4)					3.0 (-4)
Plutonium-239/240	2.43 (4) / 6.76 (3) yr			3.1 (-5)					3.1 (-5)
Rubidium-88	18 min							4.5 (1)	4.5 (1)
Rubidium-89	15 min							8.4	8.4
Ruthenium-106	1.0 yr			3.8			5.3 (-5)		3.8
Strontium-90	29 yr			3.2			1.1 (-4)		3.2
Tritium	12.3 yr	7.5 (-1)		6.04 (3)					6.04 (3)
Unidentified alpha	-			6.3 (-3)	1.0 (-6)		1.8 (-6)		6.3 (-3)
Unidentified beta-gamma	-				8.4 (-5)	8.3 (-5)	1.7 (-4)		3.4 (-4)
Xenon-133	5.3 days	3.68 (2)						5.7 (2)	9.4 (2)
Xenon-135	9.2 hr	1.47 (2)						3.9 (3)	4.1 (3)
Xenon-135m	16 min							1.7 (3)	1.7 (3)
Xenon-138	17 min							6.4 (3)	6.4 (3)
Zirconium-95	65 days			4.2 (-3)					4.2 (-3)
Totals		6.66 (2)	-0-	2.599 (5)	2.06	8.3 (-5)	4.3 (-4)	.696 (4)	2.975 (5) [b]

[a] 1.56 (7) = 1.56×10^7

[b] Details may not add up to totals because of rounding

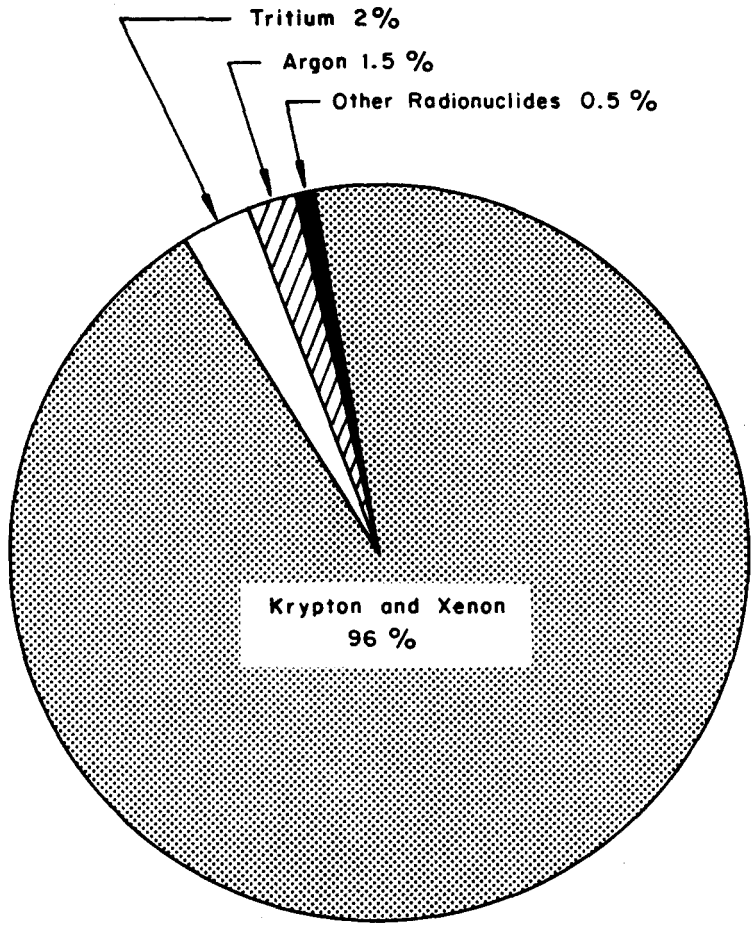


Figure III-5. Composition of Airborne Waste Released to the Atmosphere for 1974.

occur from ANL, ARA, NRF, and TAN. During 1974, the LOFT reactor was under construction and no radiological release occurred from this facility. The environmental impact from the INEL atmospheric releases is discussed below.

b. Land Commitment and Impact

Land is the total natural and cultural environment within which production takes place and commonly implies climate, soil, surface configuration, water, and location; however, in this case, only a surface area connotation is intended.

The amount of land committed to the installation of airborne waste systems is very small. Normally, the airborne waste system is an integral part of the main plant with overhead or underground piping leading directly to a stack. In some instances, filtration media are housed in an additional small structure positioned between the stack and the main plant. The total commitment of land specifically used for the airborne waste systems at INEL is estimated to be less than 5 acres of the total 571,800 acre land area of INEL.

There is a minor aesthetic consideration related to the 14 high-rise stacks at INEL. Some stacks are 250 ft high and represent an unnatural disturbance of the desert scenery.

Any impact upon land resulting from the releases of airborne radioactivity would result from air-to-surface transfer of isotopes and precipitation scavenging of airborne material. These processes are not effective for noble gases, which constitute most of the released radioactivity. Reactive gases, such as elemental iodine, and particulate materials are transferred to vegetation and soil surfaces, and much of the material which is removed from vegetation by weathering is added to radioactivity transferred directly to soil surfaces.

Long-lived radioactivity from worldwide nuclear weapons testing also has been transferred to INEL soils by the same mechanisms. ERDA Health and Safety Laboratory (HASL) data[100] show that during 1973 (the most recent year of record), 0.6 nCi/m^2 of strontium-90 and 1.0 nCi/m^2 of cesium-137 were deposited in the latitude band containing INEL. The cumulative strontium-90 and cesium-137 depositions from worldwide fallout in Southeastern Idaho as of 1973 are estimated from HASL data[101] to be about 70 and 110 nCi/m^2, respectively. These estimates are higher than the national average cumulative depositions of 65 and 100 nCi/m^2 for strontium-90 and cesium-137, respectively, and indicate that the proximity of INEL to the Nevada Test Site has more than compensated for the smaller deposition from precipitation scavenging due to the low local rainfall rate. The radioactivity is distributed beneath the soil surface as the result of rainfall and other natural processes and as the result of disturbance of the soil by man's activities.

Soil samples are routinely collected from onsite, boundary, and distant locations to estimate the levels of soil contamination which have resulted from worldwide fallout and from INEL operations. Direct radiation surveys using sensitive scintillation detectors have been conducted also to evaluate the degree of surface contamination around INEL facilities. Figure III-6 shows the areas of cesium-137 contamination in the top 4 to 5 cm of soil around INEL operating areas. In those areas where results for two 4-cm layers are available, the relaxation length for cesium-137 is estimated to be 2 cm; approximately 86% of the activity is contained in the top 4 cm. The distribution of strontium-90 around INEL facilities follows the same pattern shown for cesium-137 in Figure III-6; however, strontium-90 is generally more mobile in soil-water environments than cesium-137. Relaxation lengths for strontium-90 from worldwide fallout may be 6 to 10 cm or greater; INEL data indicate that relaxation lengths for strontium-90 in soil may be only 3 to 4 cm. Hence, the strontium-90 observed in the top 4 cm may represent from 33 to 73% of the total deposition.

During 1974, 3 Ci of strontium-90 and 7 Ci of cesium-137 were released from INEL facilities. The highest annual average air concentrations at a point of public access on or around INEL were estimated to be 19 and 40 fCi/m^3 for strontium-90 and cesium-137, respectively. Air-to-surface transfer and precipitation scavenging of this airborne

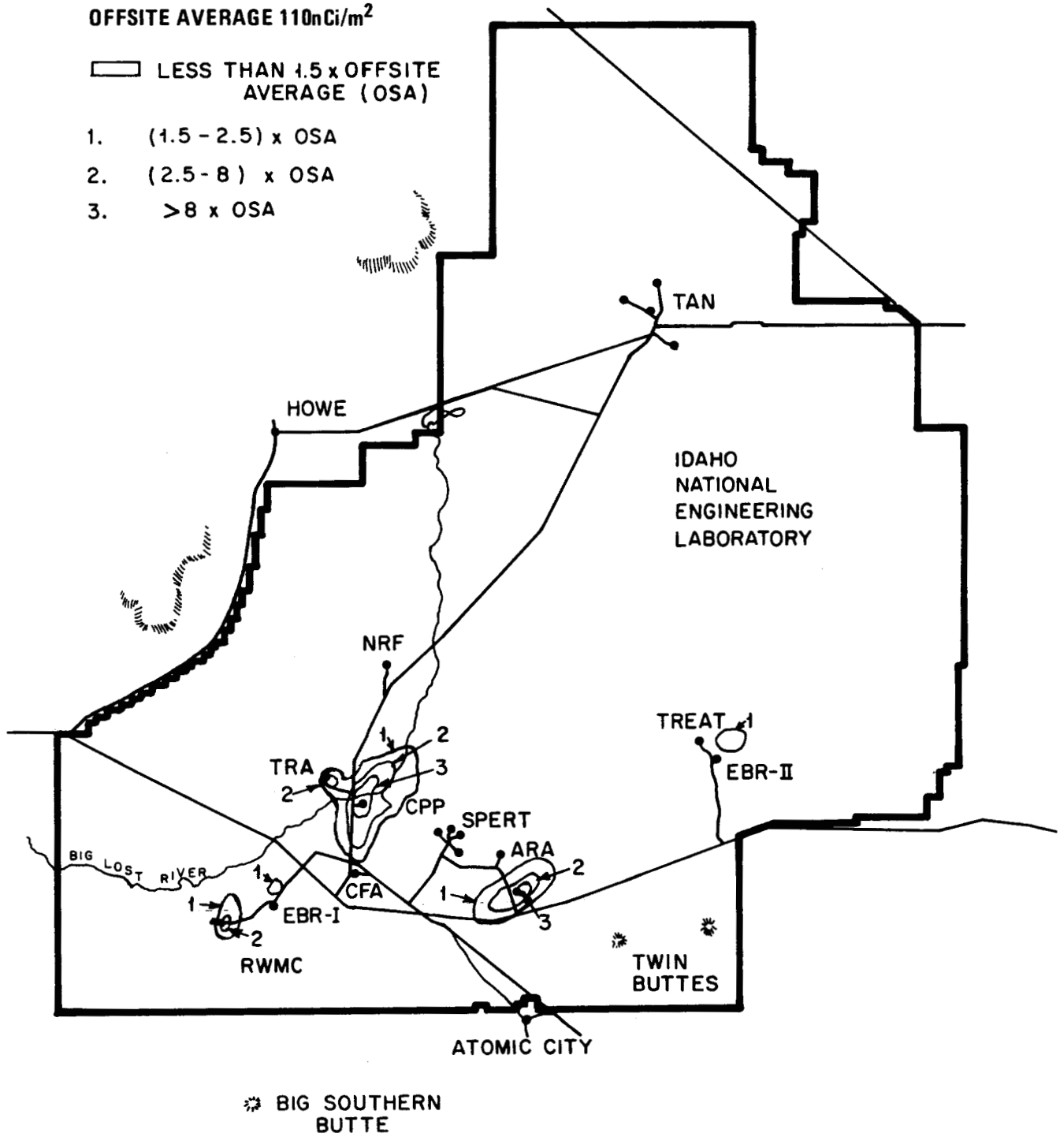


Figure III-6. Concentrations of Cesium-137 in Soil Around INEL Facilities.

material in 1974 would result in the deposition of 3.3 nCi/m^2 of strontium-90 and 6.9 nCi/m^2 of cesium-137 at the point of maximum air concentration; the average deposition on INEL and immediately adjacent lands of these two isotopes from INEL releases during 1974 is one-tenth of the maximum or $\sim$0.3 nCi/m^2 for strontium-90 and $\sim$0.7 nCi/m^2 for cesium-137.

The results of direct radiation monitoring show patterns similar to that of Figure III-6. Figure III-7 is a map of exposure rates obtained during 1973 by monitoring of direct radiation levels using portable survey instruments held 3 ft above the ground. The areas of surface contamination are observed to be mainly in the immediate vicinity of the operating areas. The radiation levels return to background values as one moves away from these areas. The exposure rates shown in Figure III-7 through Figure III-22 are not the result of surface contamination alone, but include contributions from direct radiation from materials inside facility boundaries, such as stored fuel, contaminated pond water, contaminated equipment, and airborne effluents. The increase in exposure rate due to radioactivity in disposal ponds and ditches can be seen in Figures III-8, -10, -12, -14, -17, -18, and -19. The activity around the Big Southern Butte is increased background associated with geologic exposure of excess rhyolite.

Public access to INEL is limited and controlled for administrative reasons. There are no restrictions imposed because of soil contamination or direct radiation levels, except in the area immediately adjacent to waste disposal areas.

During August and September of 1974, an aerial survey of INEL was performed by EG&G, Las Vegas under contract to the ERDA Division of Operational Safety. An array of 39 NaI(Tl) crystals, 5 in. in diameter and 2 in. thick, was carried in pods by a helicopter at an altitude of 500 ft above the terrain. The east-west survey lines were flown at 1,000-ft intervals across INEL; nearly 2,900 flight line miles were flown during the survey. The land area scanned by the detectors flown at 500 ft is circular with an effective diameter of $\sim$1,250 ft.

Both gross count data and gamma ray spectra were obtained from the survey system. The principal manmade nuclides identified by gamma spectrometry were cobalt-60 and cesium-137. Figures III-23 through III-25 show the gross count data from manmade isotopes and the exposure rates derived from the cobalt-60 and cesium-137 spectral data. The derived exposure rates for cobalt-60 and cesium-137 assume a surface distribution; however, contaminated pond water, contaminated waste, and contaminated equipment inside facility boundaries are known to contribute significantly to the radiation fields. The fact that an exposure rate isopleth extends beyond a facility's boundary does not imply necessarily the spread of surface contamination.

Soil samples have been analyzed for naturally occurring potassium-40, uranium-238 plus daughter isotopes, and thorium-232 plus daughter

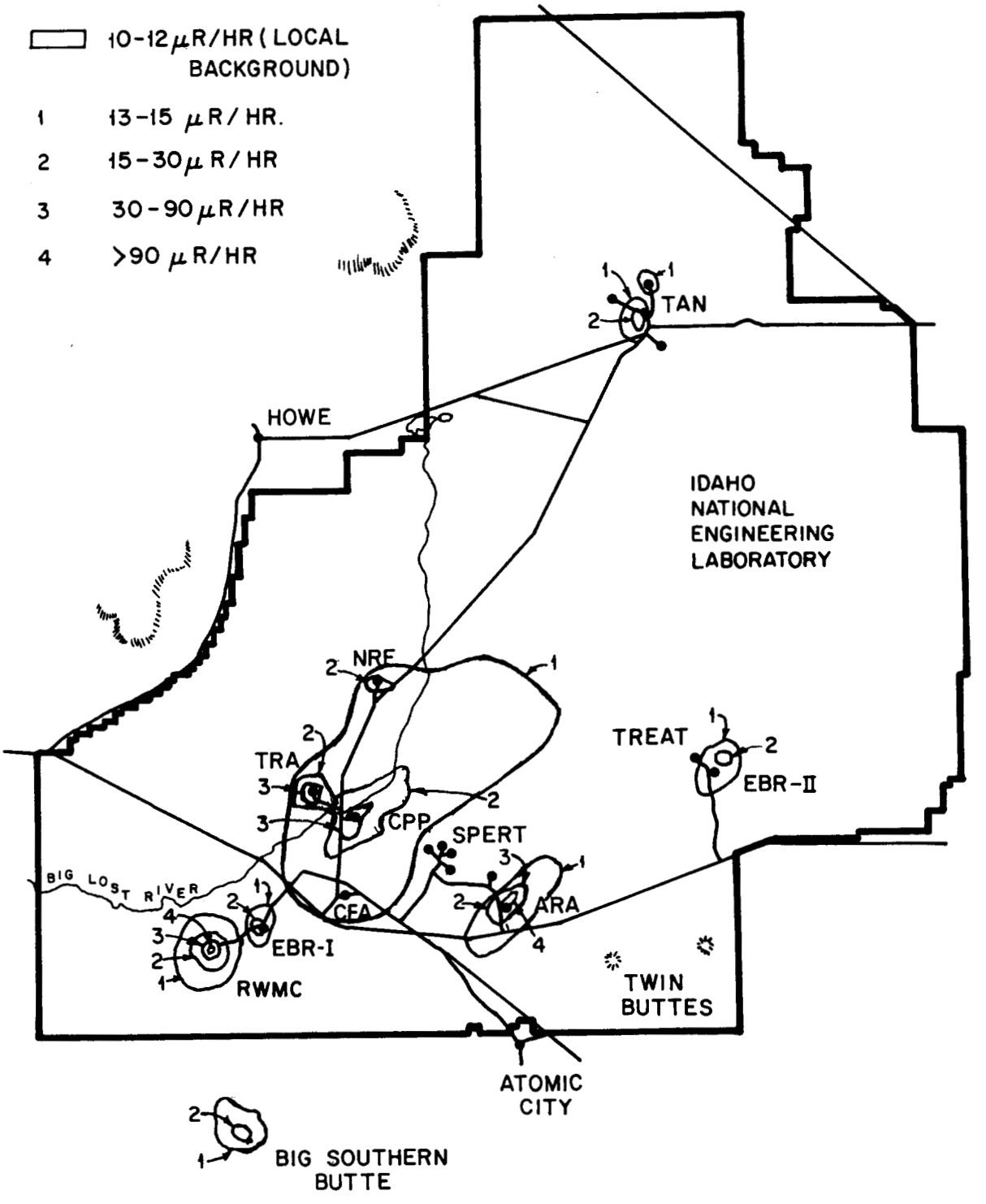


Figure III-7. Direct Radiation Exposure Rates Around INEL Facilities.

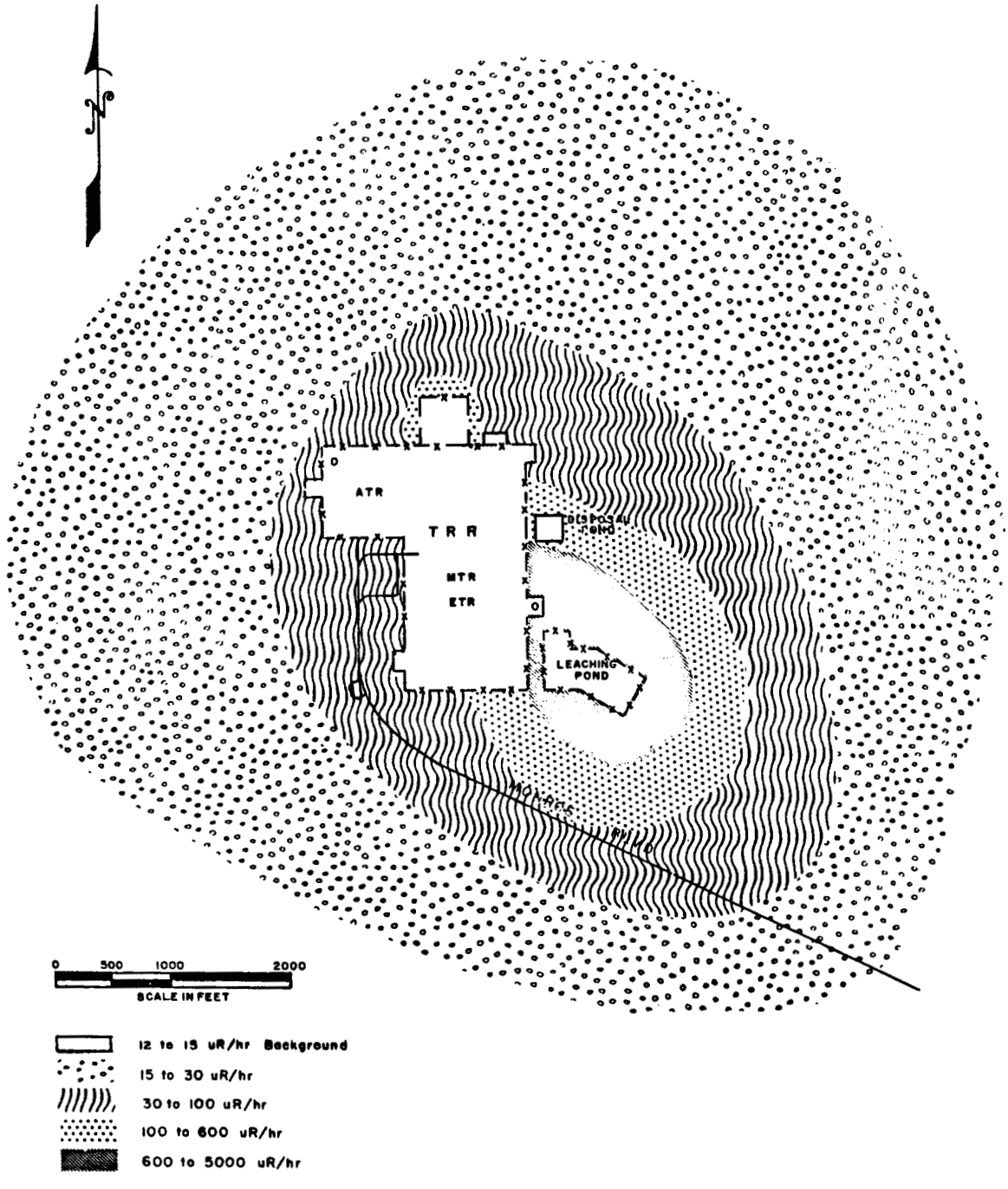


Figure III-8. Gamma Radiation Intensities Outside Enclosed TRA Facility.

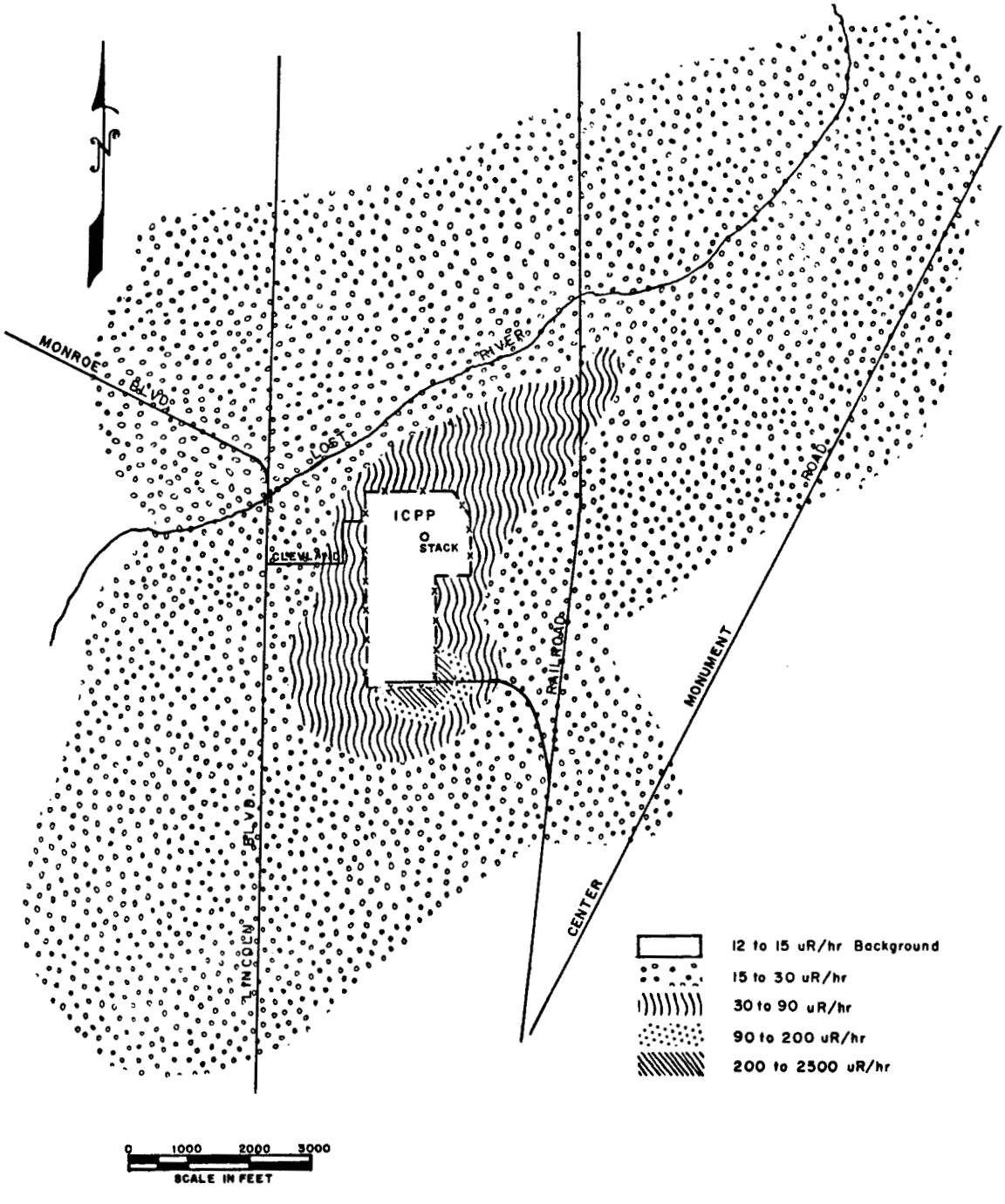


Figure III-9. Gamma Radiation Intensities Outside Enclosed ICPP Facility.

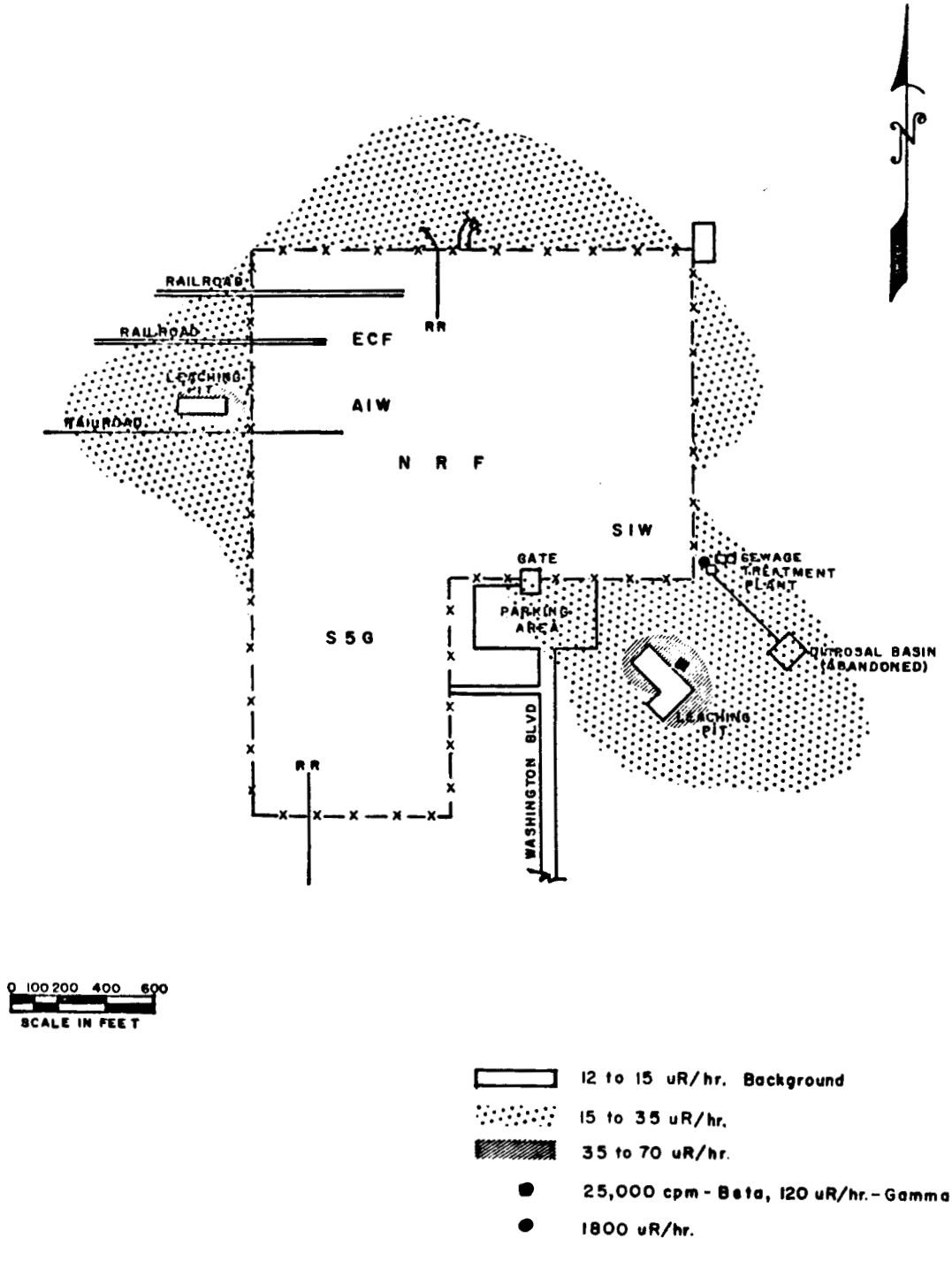


Figure III-10. Gamma Radiation Intensities Outside Enclosed NRF Facility.

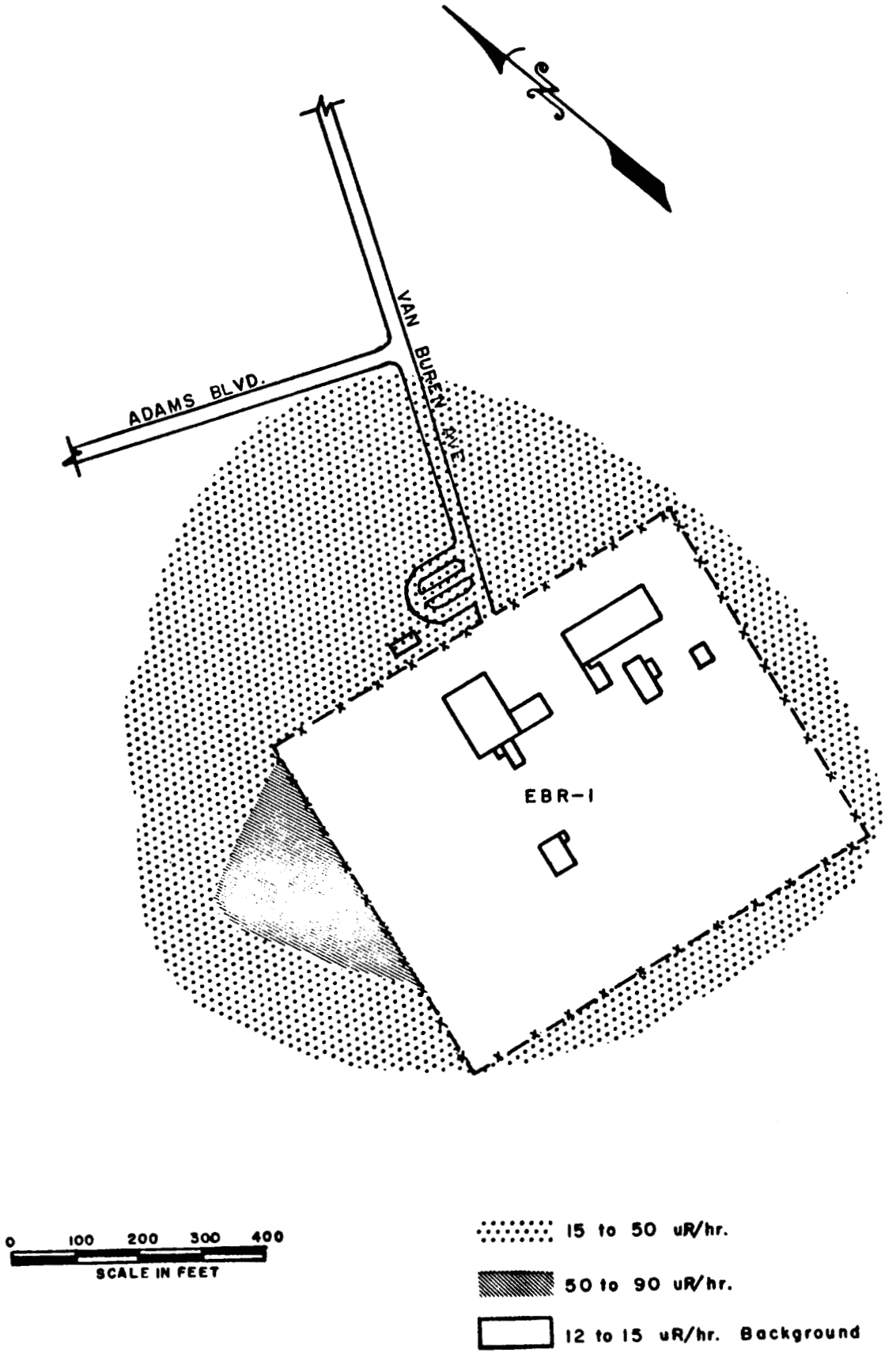


Figure III-11. Gamma Radiation Intensities Outside Enclosed EBR-I Facility.

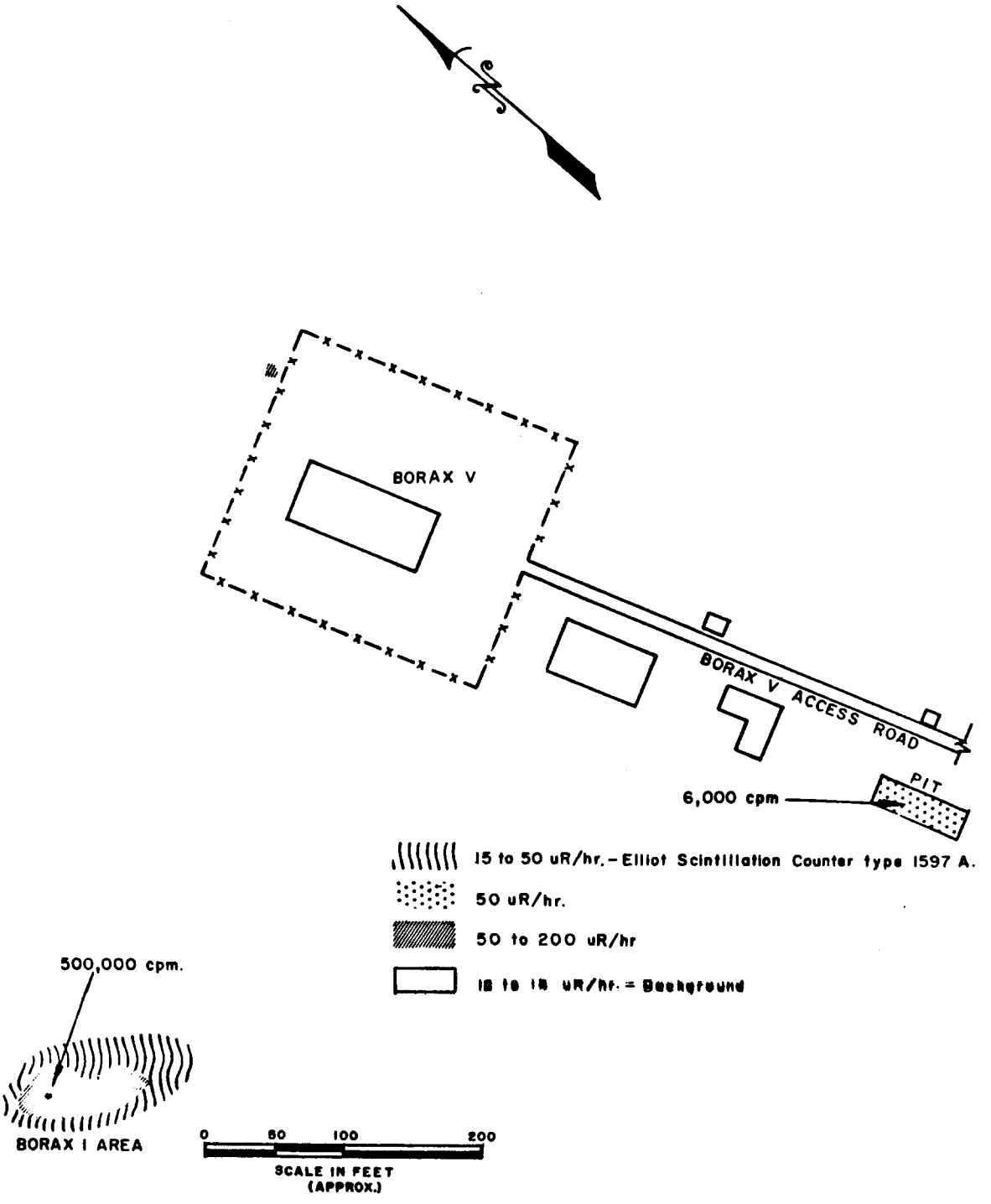


Figure III-12. Gamma Radiation Intensities Outside Enclosed BORAX Facility.

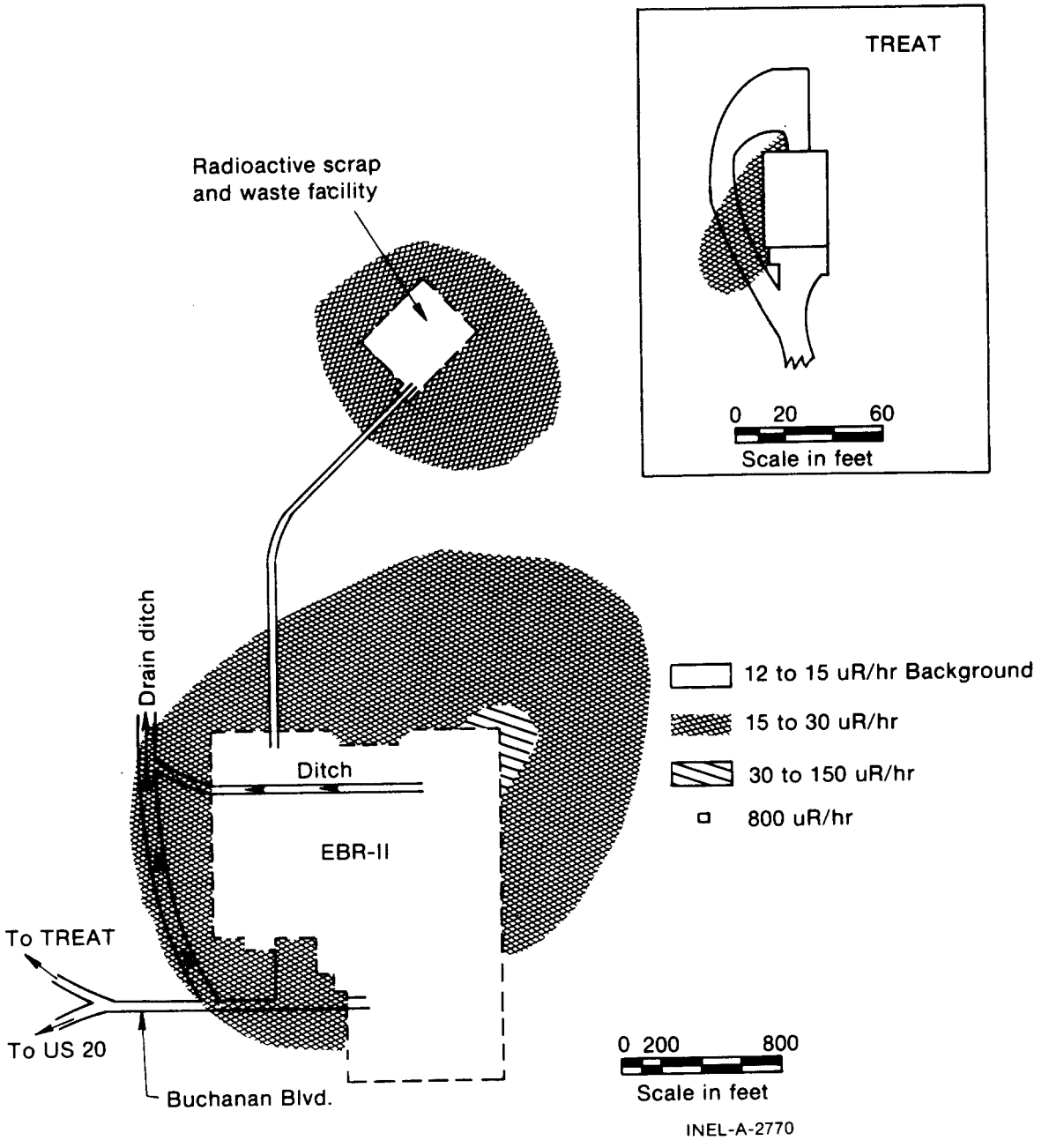


Figure III-13. Gamma Radiation Intensities Outside the Enclosed EBR-II Facility.

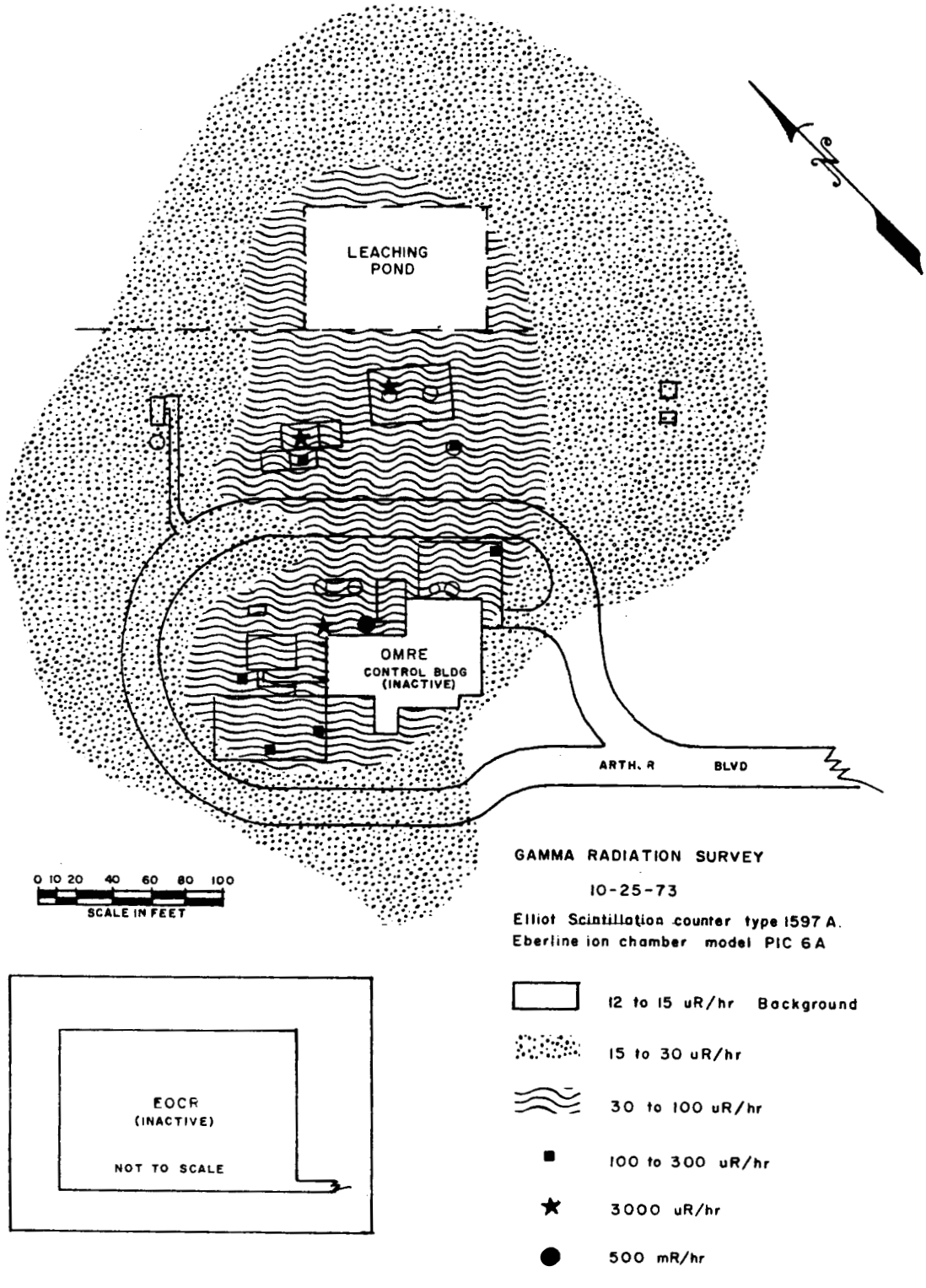


Figure III-14. Gamma Radiation Intensities Outside the Enclosed OMRE and EOCR Facilities.

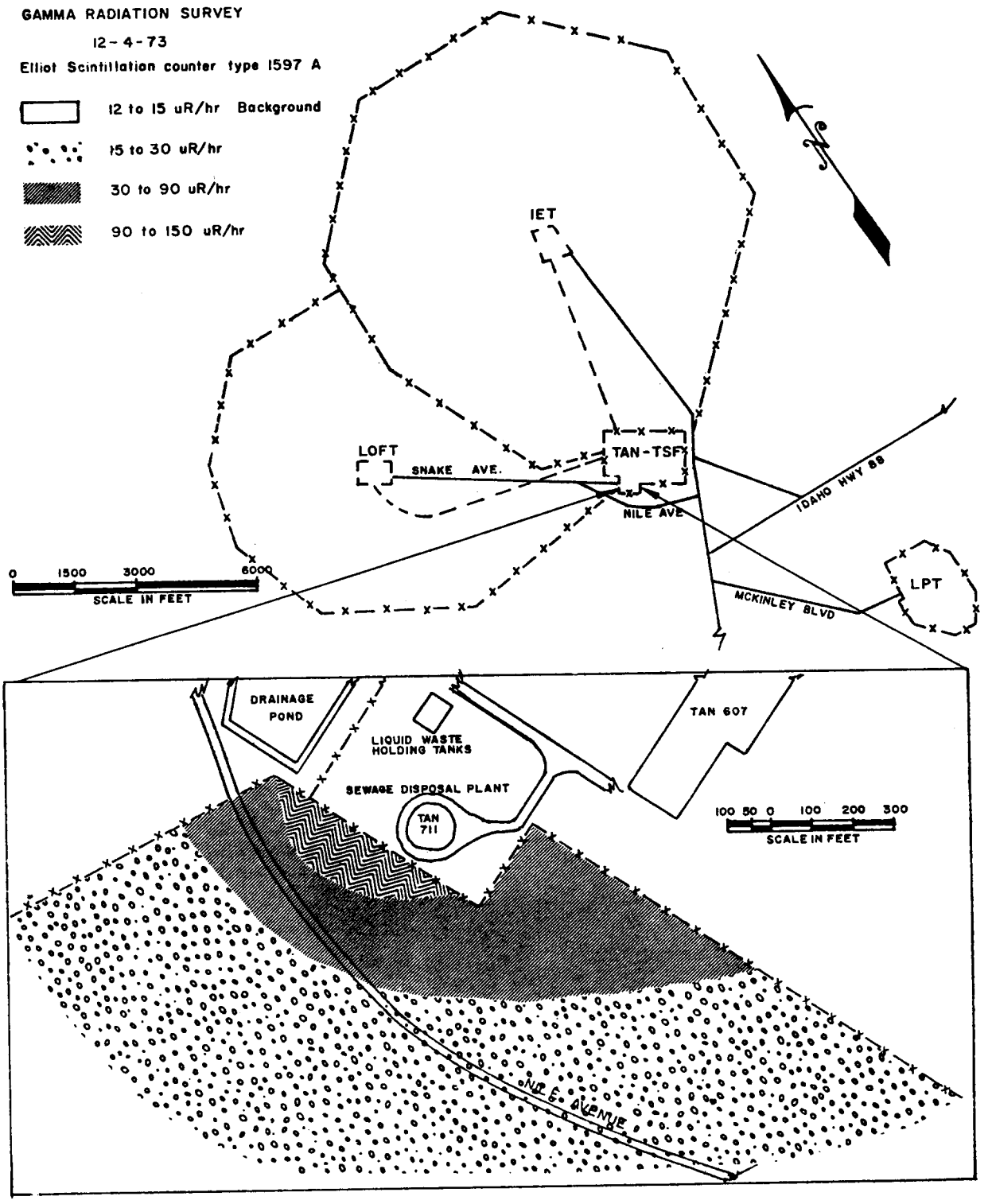


Figure III-15. Gamma Radiation Intensities Outside the TAN-TSF Facility.

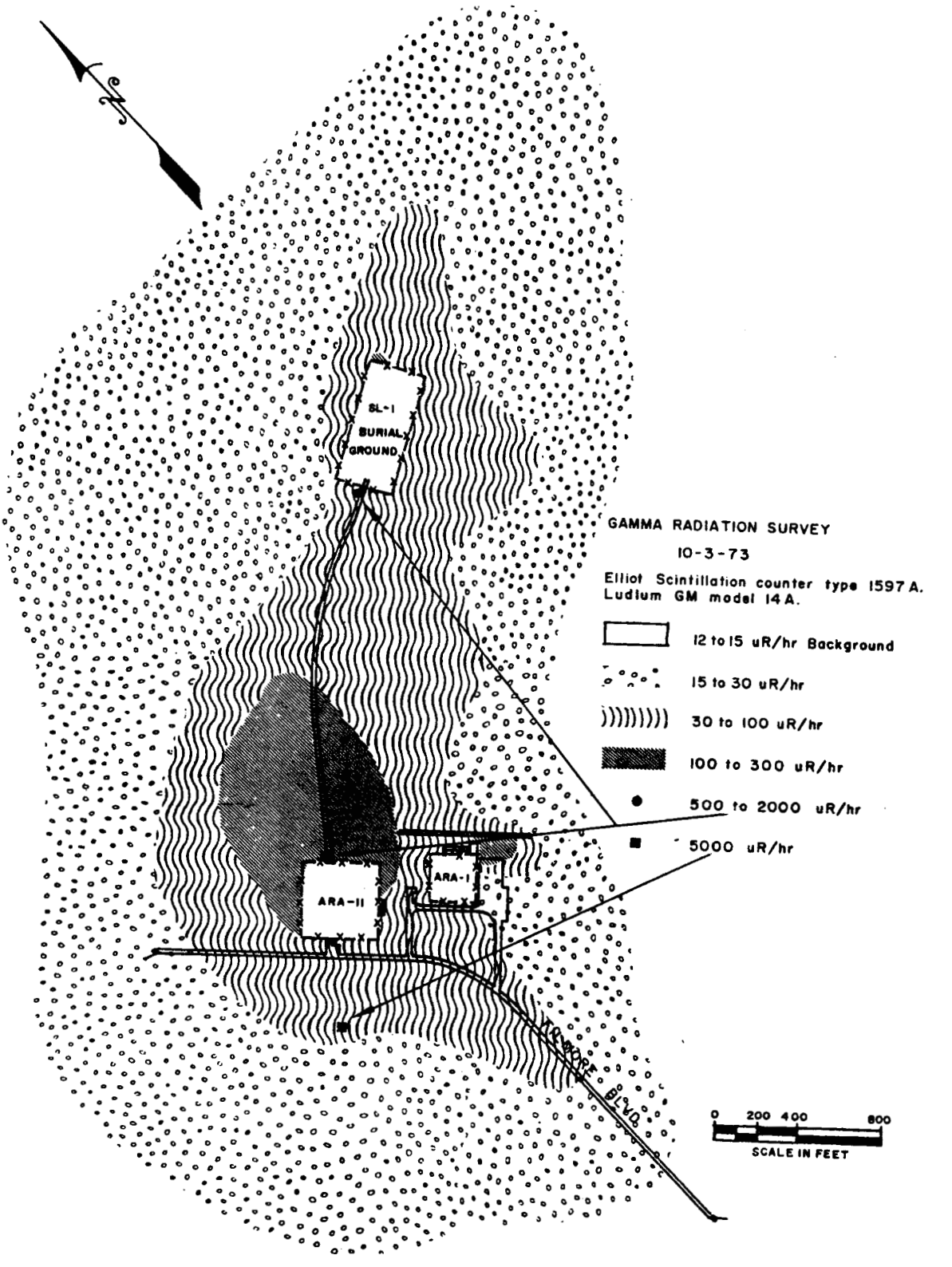


Figure III-16. Gamma Radiation Intensities Outside the Enclosed ARA-I, ARA-II, and SL-1 Burial Ground.

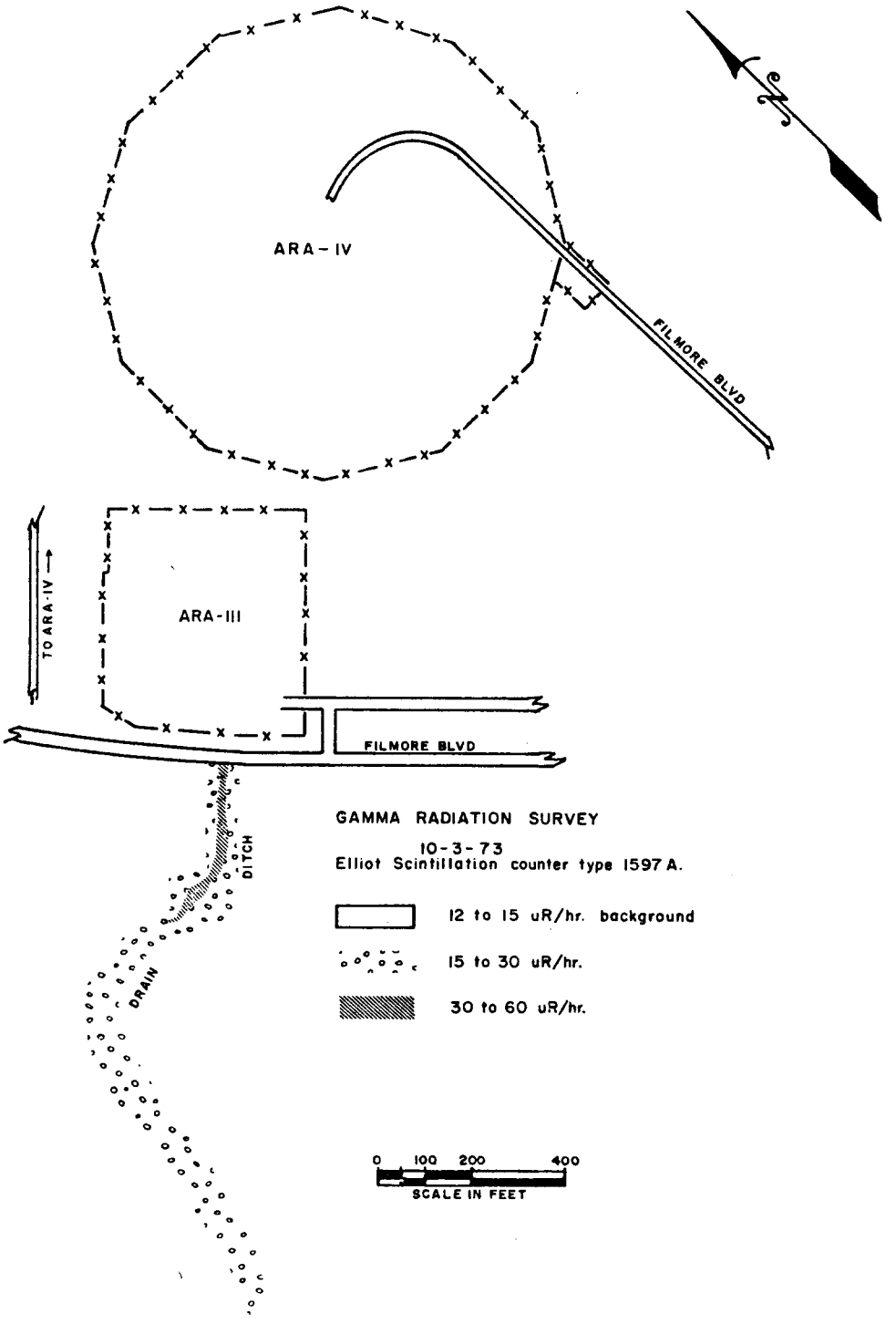


Figure III-17. Gamma Radiation Intensities Outside the Enclosed ARA-III and ARA-IV Facilities.

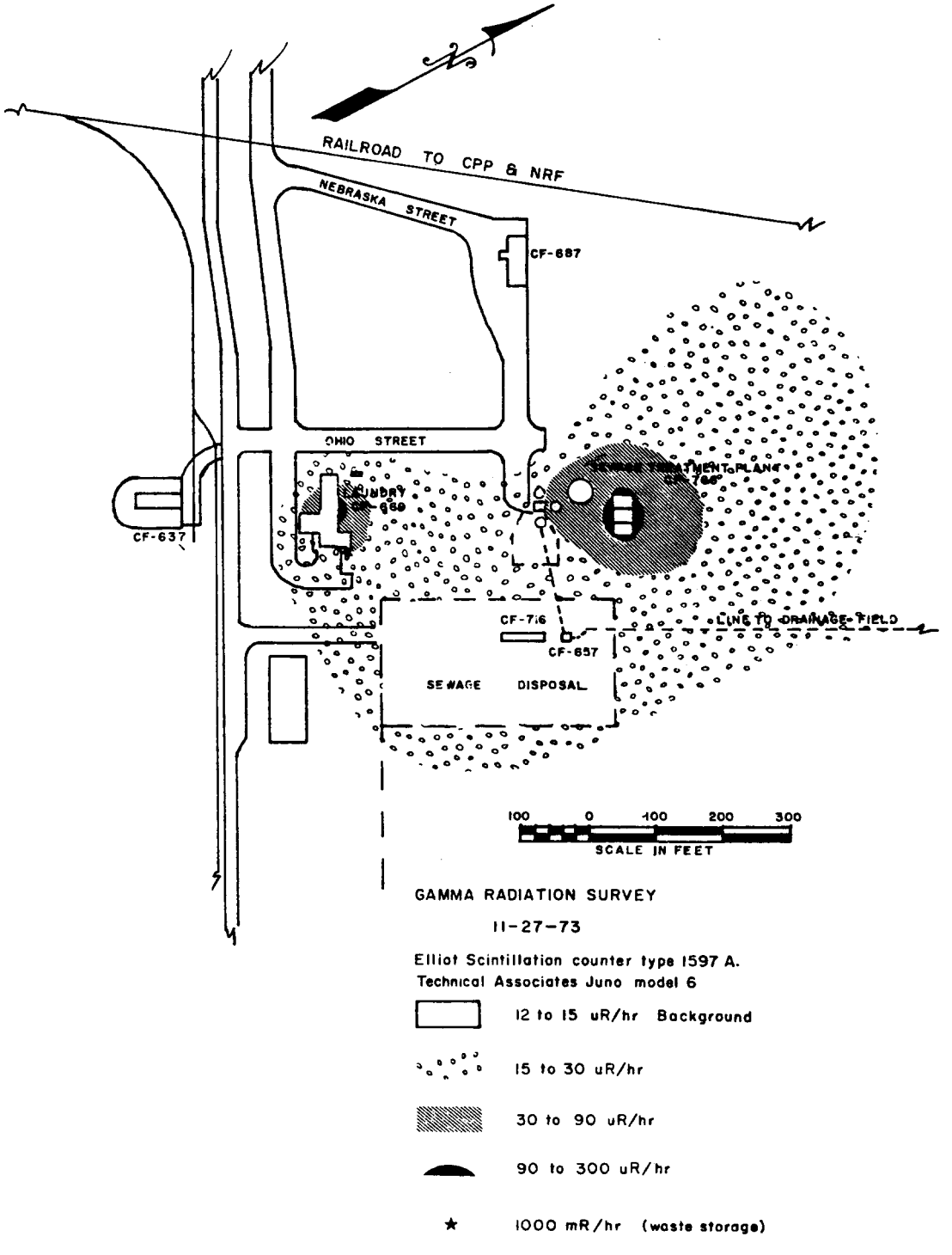


Figure III-18. Gamma Radiation Intensities Outside the Enclosed CFA Laundry and Sewage Treatment Plant.

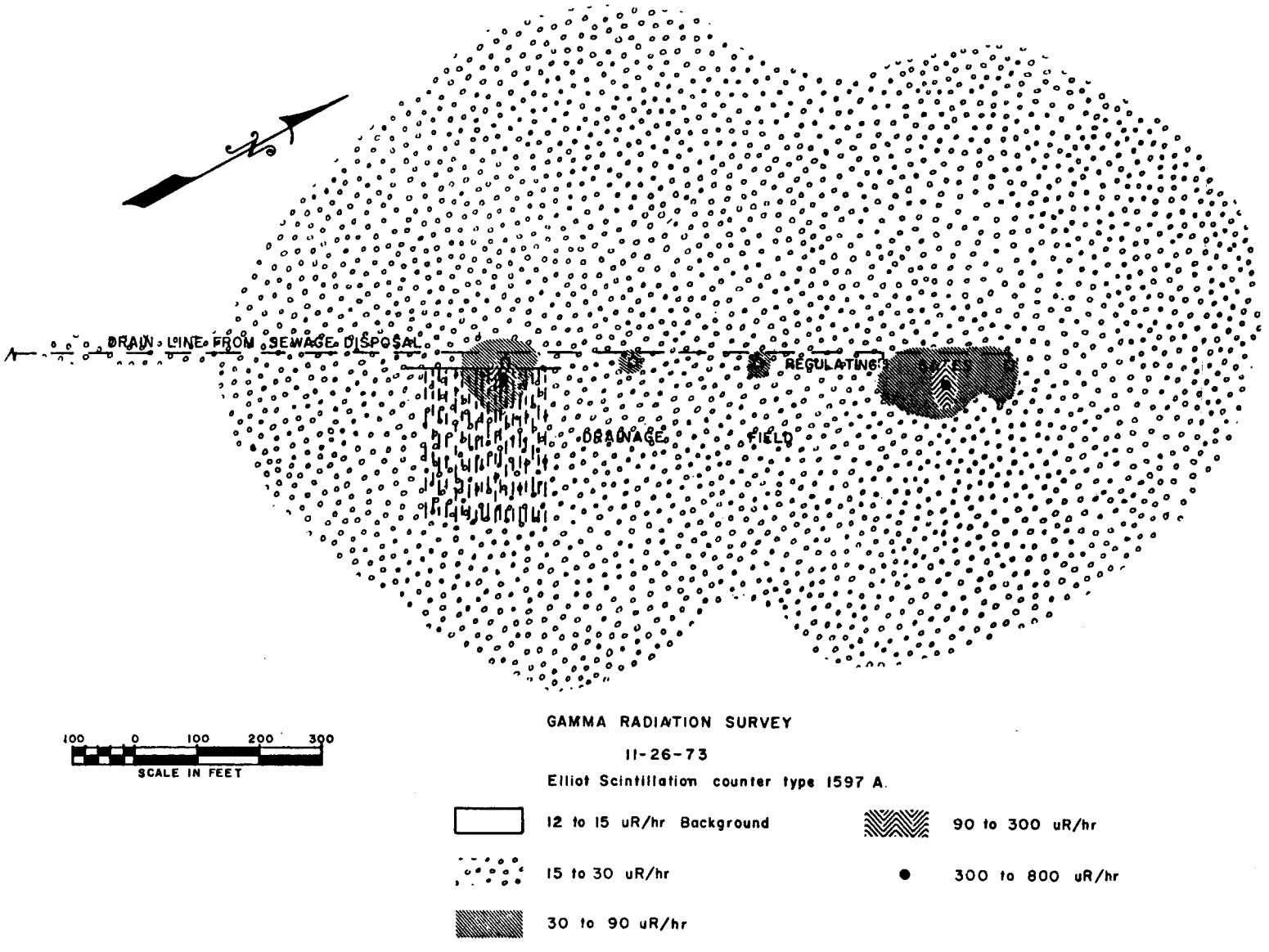


Figure III-19. Gamma Radiation Intensities at the CFA Sewage Disposal Drainage Field.

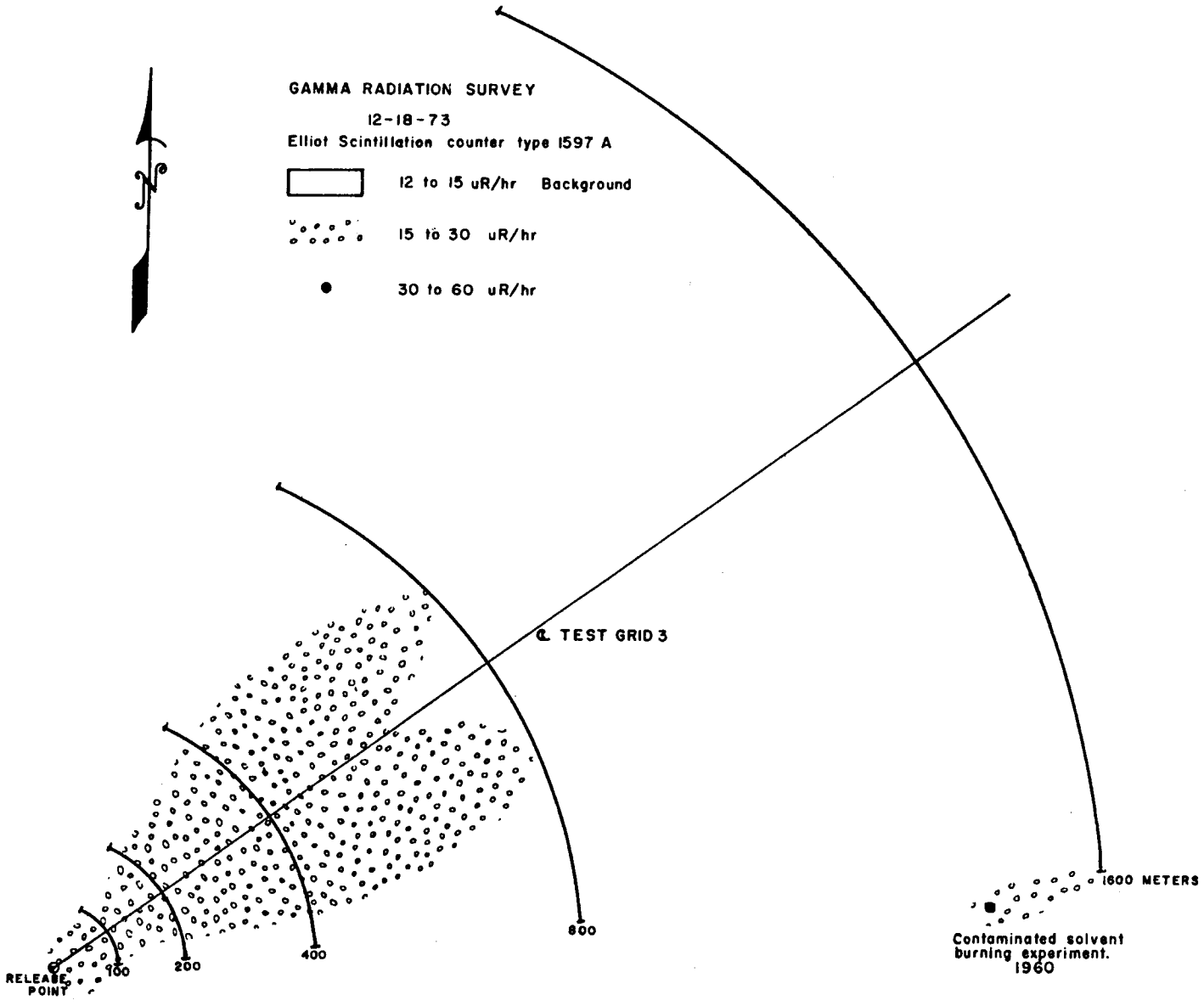


Figure III-20. Gamma Radiation Intensities at Test Grid III.

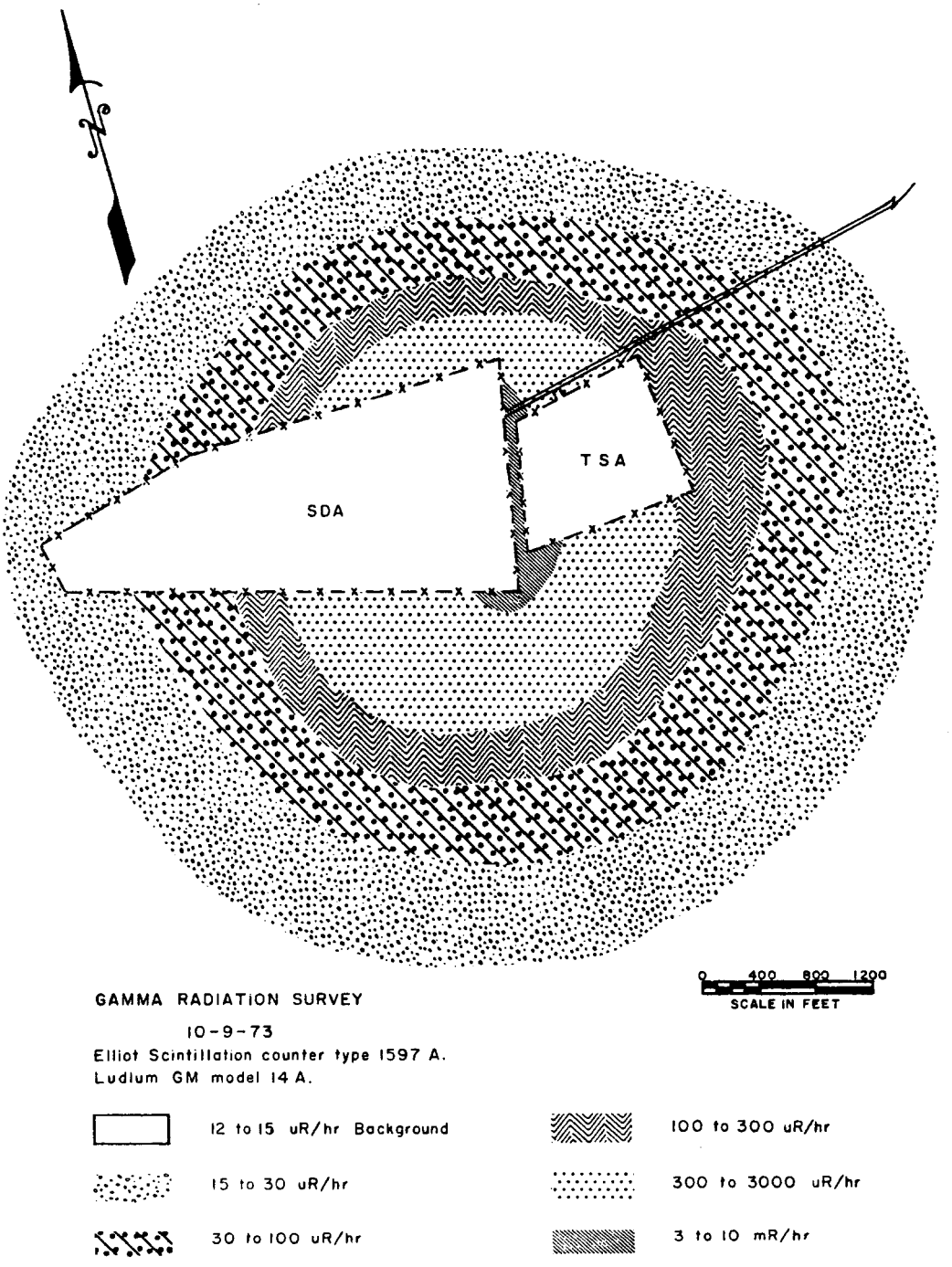


Figure III-21. Gamma Radiation Intensities Outside the Enclosed Radioactive Waste Management Complex.

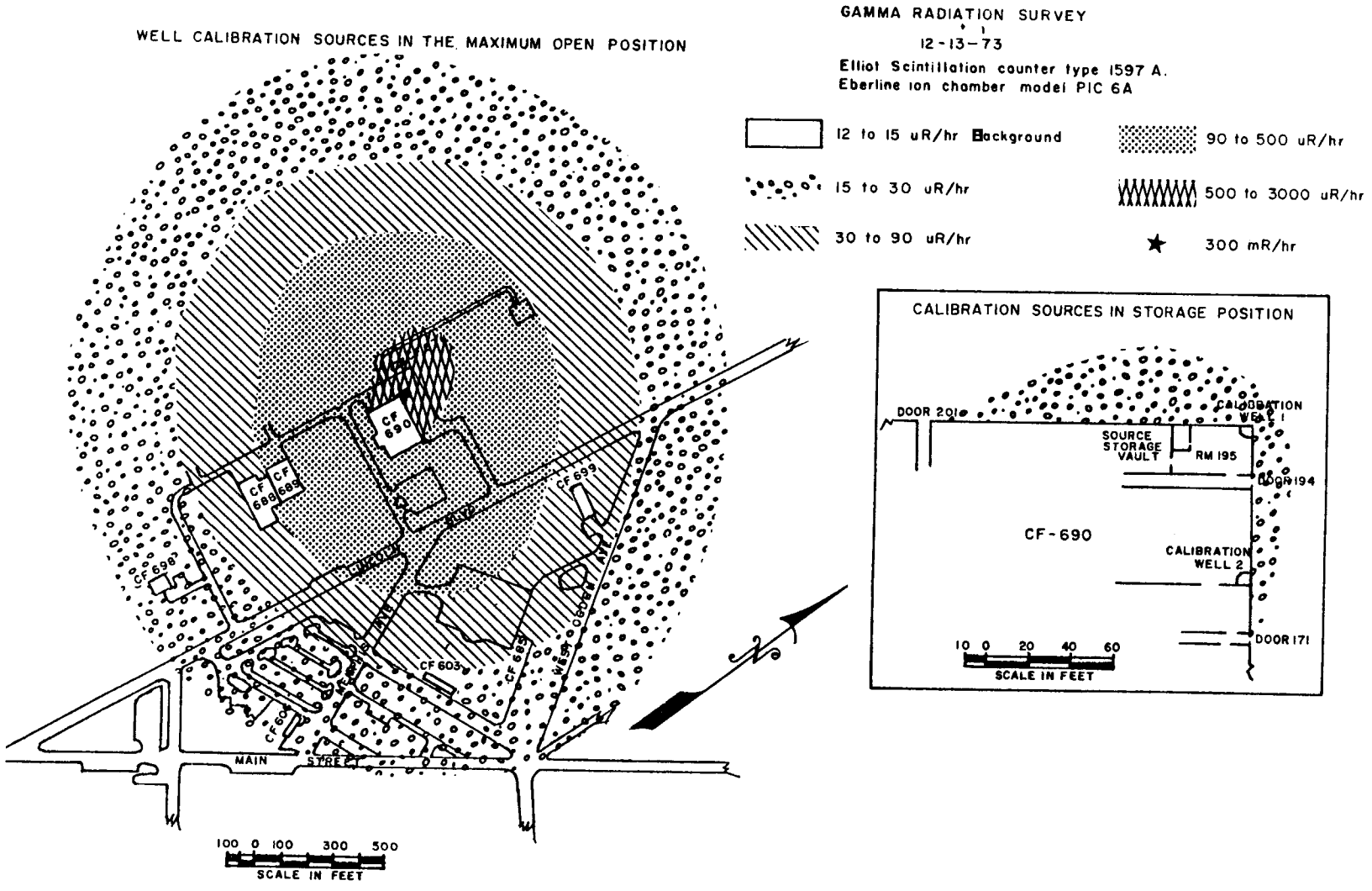


Figure III-22. Gamma Radiation Intensities Outside the Health Services Laboratory, CF-690.

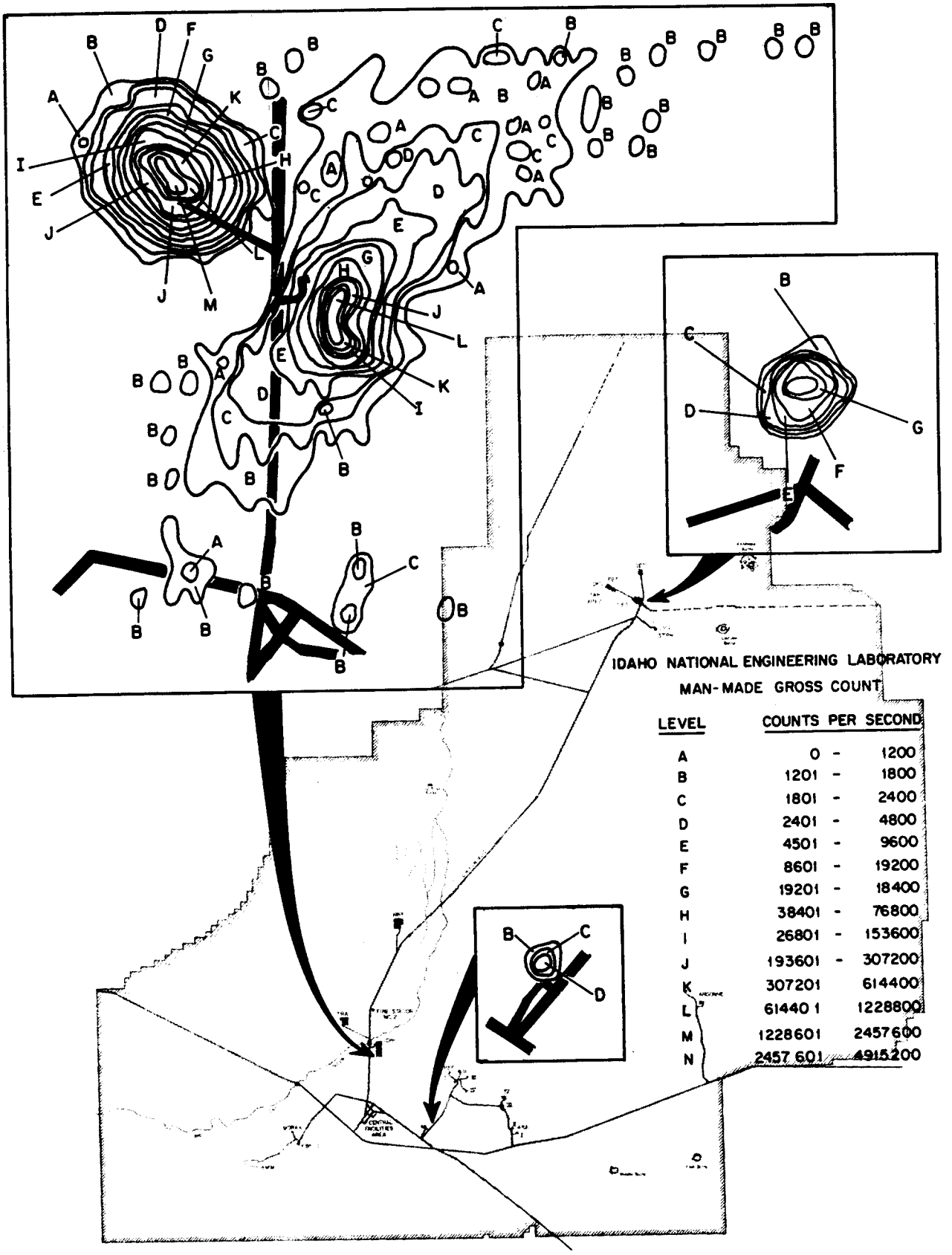


Figure III-23. Gross-Count Data from EG&G Aerial Survey of INEL in 1974.

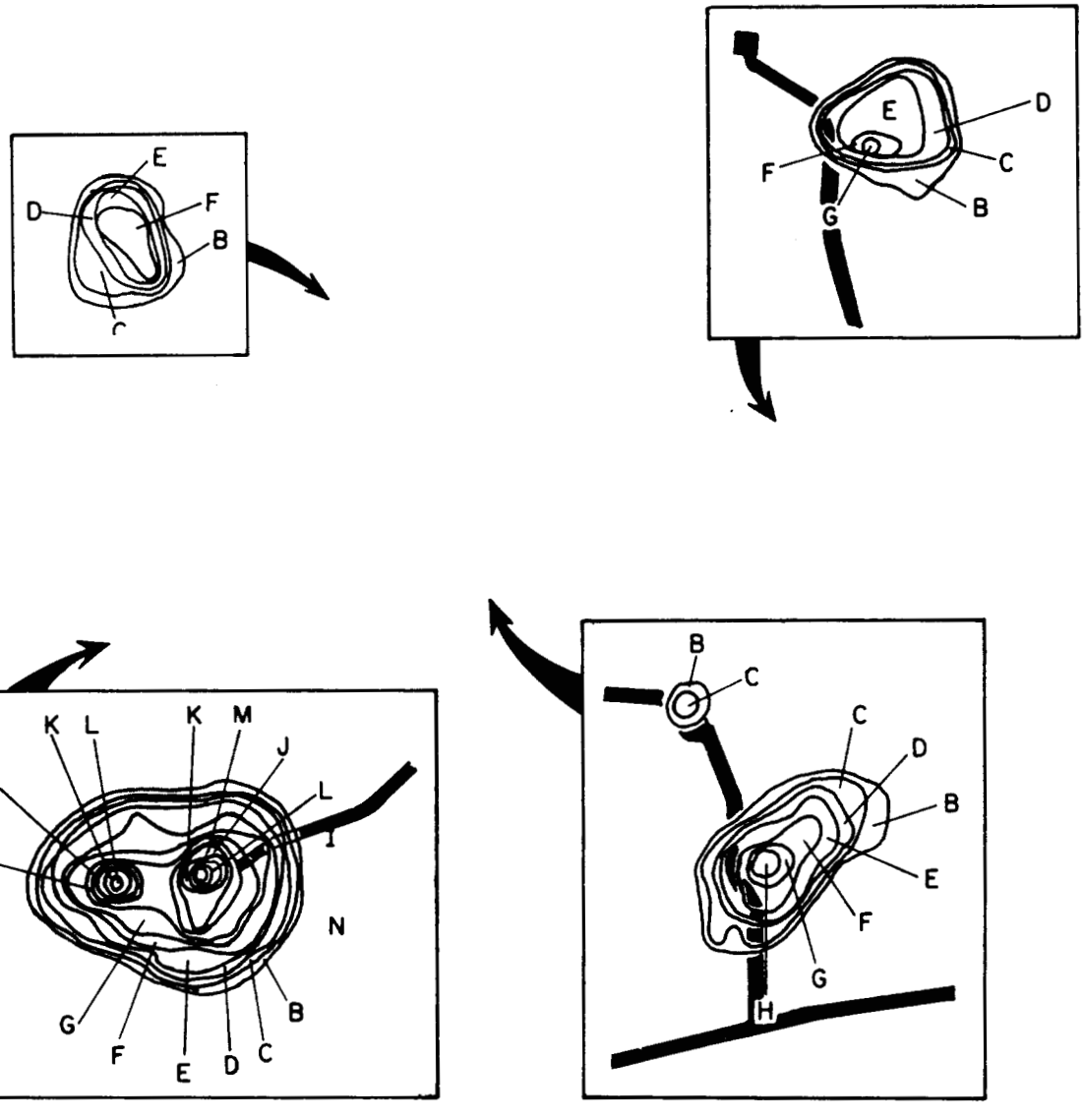
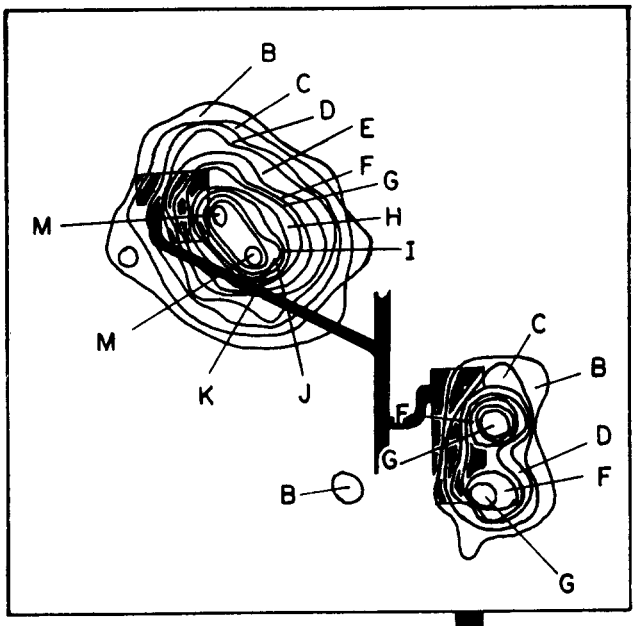
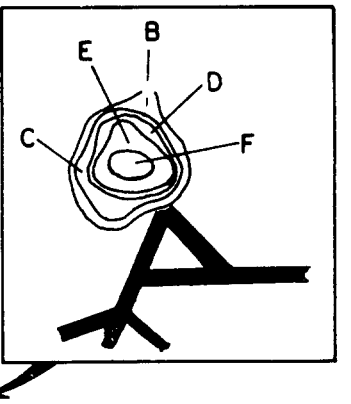


Figure III-23. (continued) Gross-Count Data from EG&G Aerial Survey of INEL in 1974.

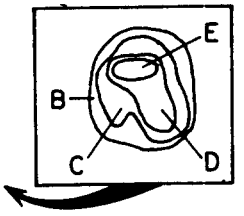


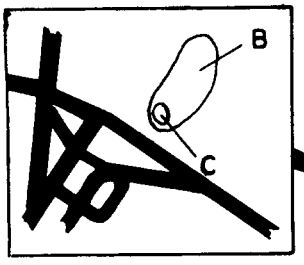


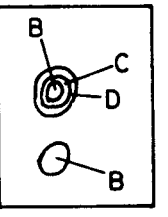
IDAHO NATIONAL ENGINEERING LABORATORY

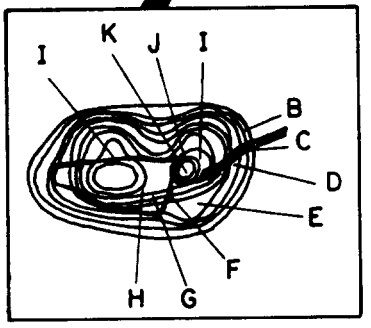
GAMMA EXPOSURE RATES FOR Co^{60}

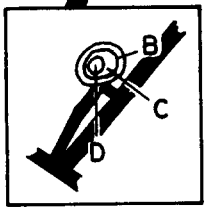
LEVEL	EXPOSURE RATE - uR/hr		
A	0	-	2.7
B	2.74	-	5.4
C	5.44	-	10.8
D	10.84	-	21.6
E	21.64	-	43.2
F	43.24	-	86.4
G	86.44	-	172.8
H	172.84	-	345.6
I	345.64	-	691.2
J	691.24	-	1382.4
K	1382.44	-	2764.8
L	2764.84	-	5529.6
M	5529.64	-	11059.2
N	11059.24	-	22118.4











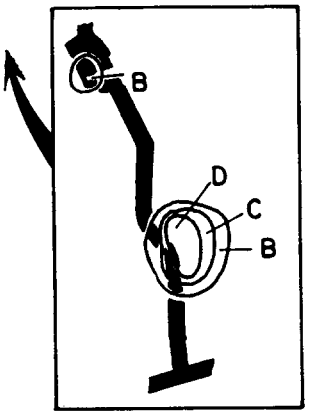


Figure III-24. Cobalt-60 Exposure Rates Derived from EG&G Aerial Survey in 1974.

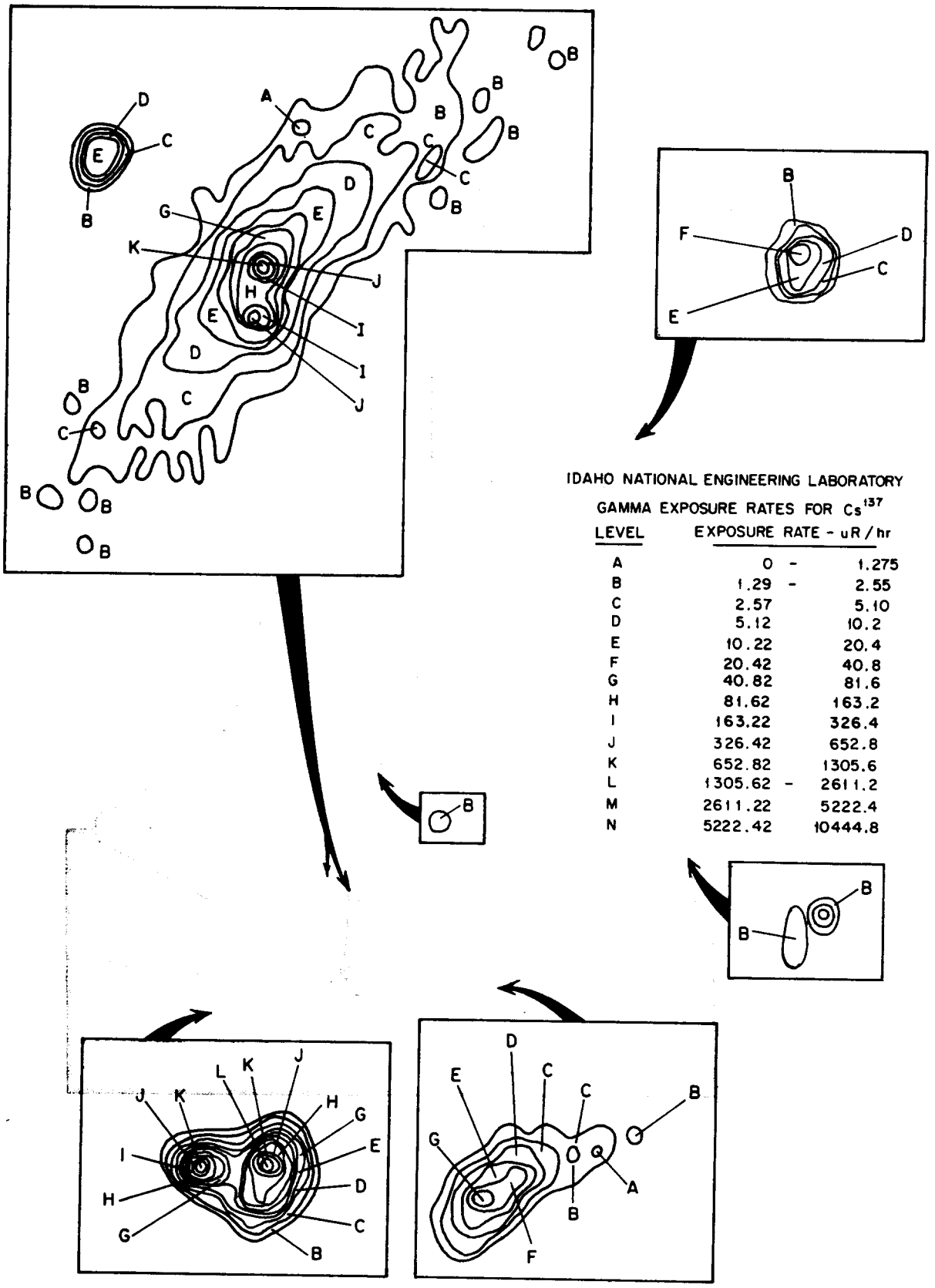


Figure III-25. Cesium-137 Exposure Rates Derived from EG&G Aerial Survey of INEL in 1974.

isotopes at both offsite and onsite locations. Concentrations of these radionuclides in the INEL environs are higher than the average for upper crustal material and reflect the silicic volcanics and paleozoics present on both sides of the plain rather than the basalt which covers most of the plain. The soil samples show the effect of paleozoic limestone erosion on both sides of the plain where rivers meet the plain; the potassium content is decreased and the uranium content is increased relative to the thorium concentration. These data on soils have been used to predict gamma ray exposure rates due to the natural radioactivity in the soils. The total calculated exposure rate of 85 mrem/yr plus 60 mrem/yr from cosmic rays yield a calculated background dose of 150 mrem/yr which is higher than that measured with thermoluminescent dosimeters at locations away from the direct radiation sources near operating areas (discussed in Section II.C.13).

If ICPP continues to release particulate radionuclides at the same rates as in 1974, levels of long-lived radionuclides in soil will increase until the yearly deposition is balanced by the yearly loss due to radioactive decay. The highest equilibrium levels of strontium-90 and cesium-137 in soil at-points of public access or permit grazing would be, respectively, 130 and 300 nCi/m^2 (above worldwide fallout levels) if the location and magnitude of the highest annual average air concentration and the rainfall rate remained the same throughout the ∿90-yr period required to achieve these levels. The average equilibrium concentrations in the INEL environment would be much lower, less than 10% of the above highest equilibrium value for each isotope (above worldwide fallout levels). Equilibrium levels of shorter-lived isotopes are achieved more quickly; if the 1974 release rates of 3.8 and 0.7 Ci/yr are maintained, maximum contamination levels of 6.0 and 0.8 nCi/m^2 of ruthenium-106 and cerium-144, respectively, would be reached in about 3 yr. The average releases of these two isotopes during the period 1963 through 1974 are substantially greater than the 1974 values. If the 12-yr average release rates of 51 and 17 Ci/yr were to continue, the maximum soil concentrations would reach 80 and 20 nCi/m^2 for ruthenium-106 and cerium-144, respectively, as a consequence of ICPP releases. Average soil concentrations in areas of public access or animal grazing by permit would be less than 10 nCi/m^2 for these isotopes. This may be compared with the ∿25 nCi/m^2 concentration which has been observed in INEL boundary and distant offsite soil samples following deposition of relatively fresh fallout from weapons testing.

The concentrations of plutonium-238, plutonium-239, and americium-241 in the top 4 to 5 cm of soil around INEL site facilities are shown in Figures III-26, III-27, and III-28, respectively. Fallout concentrations of these radionuclides have been determined by analyzing numerous samples collected from locations not affected by site operations. The analysis of background samples taken from 1970-1975 show that: (1) the mean fallout plutonium-238 concentration is 0.15 nCi/m^2 with individual samples having concentrations as high as 0.37 nCi/m^2, (2) the mean fallout plutonium-239 concentration is 1.06 nCi/m^2 with individual

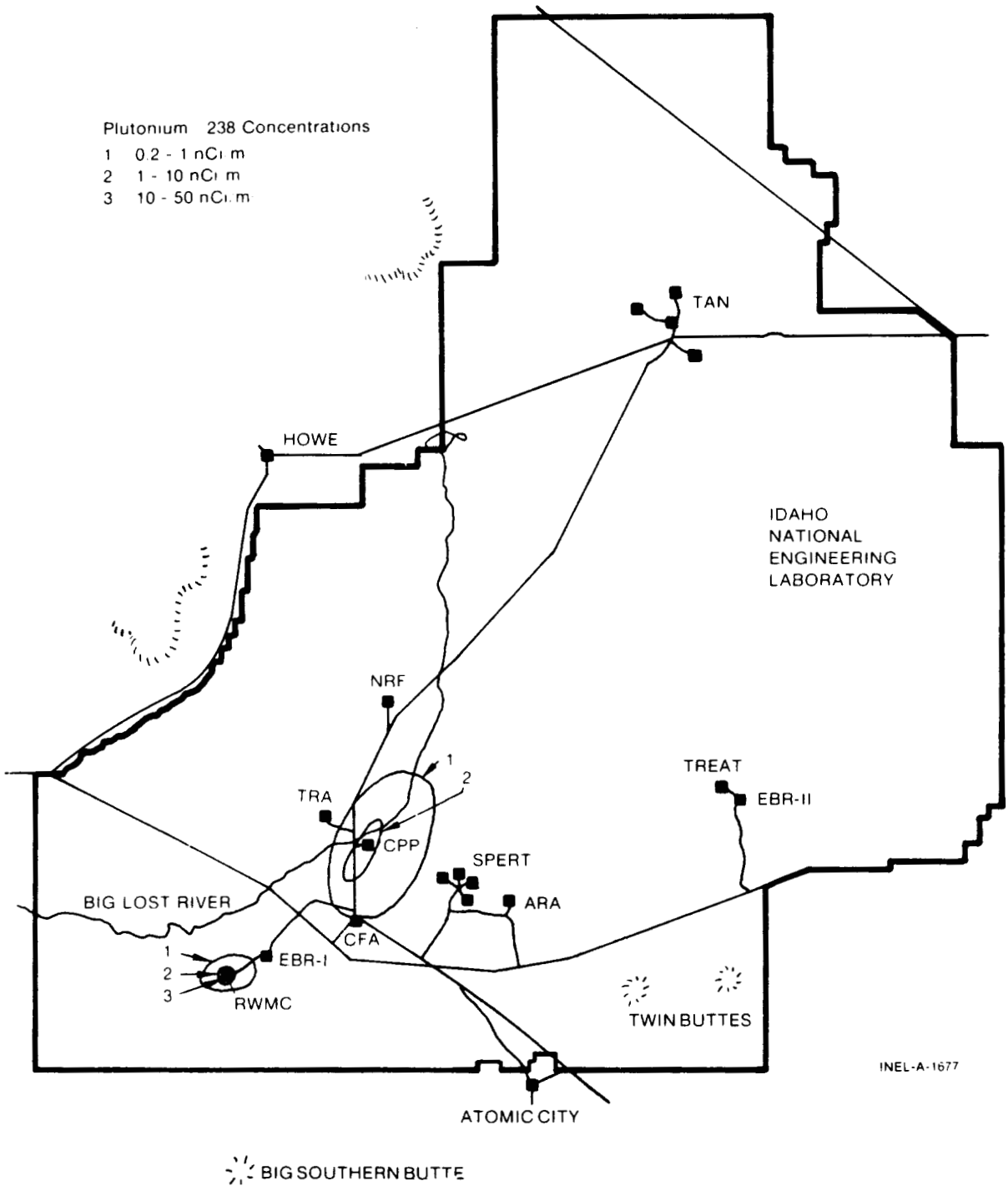


Figure III-26. Concentrations of Plutonium-238 in Soils Outside INEL Site Facility Perimeters.

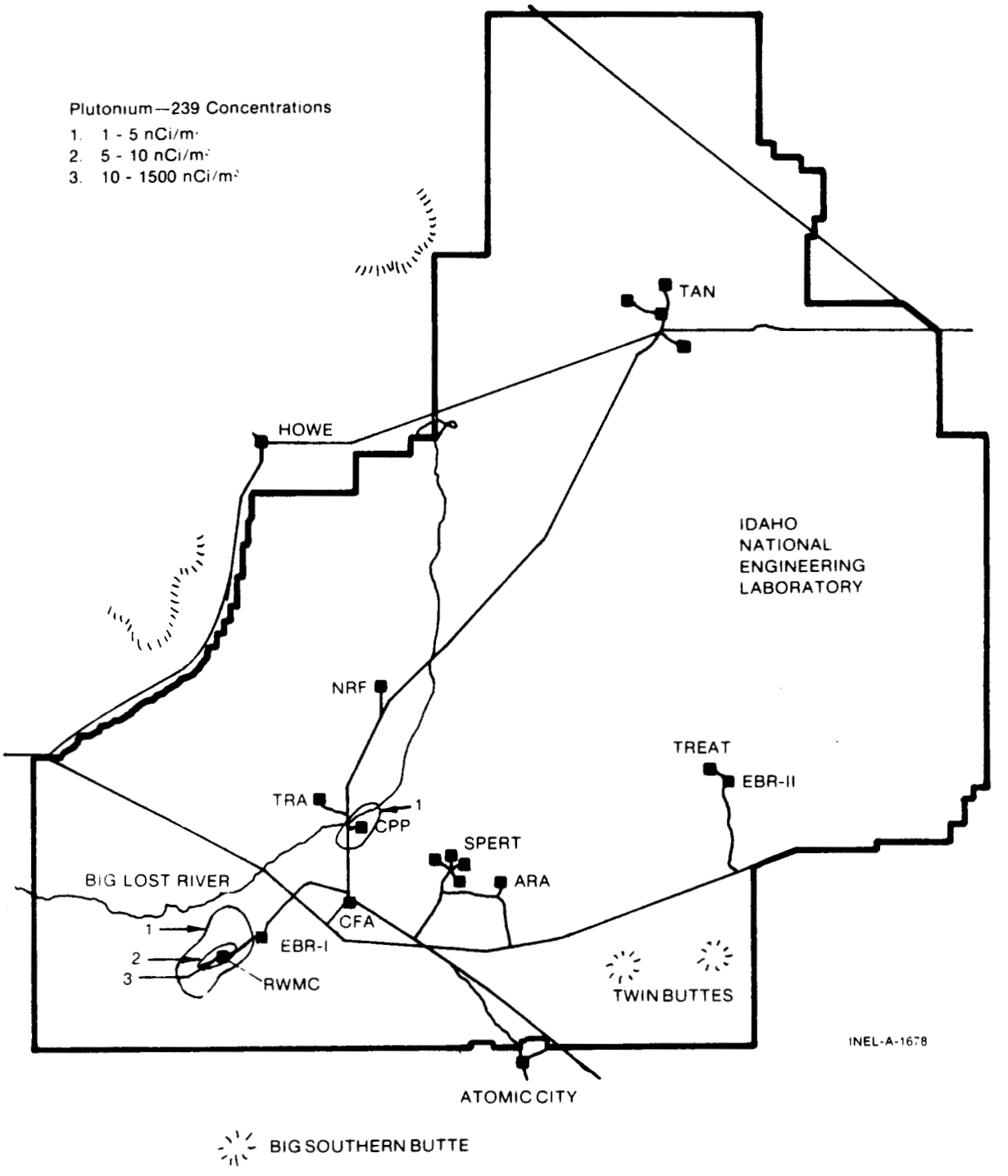


Figure III-27. Concentrations of Plutonium-239 in Soils Outside INEL Site Facility Perimeters.

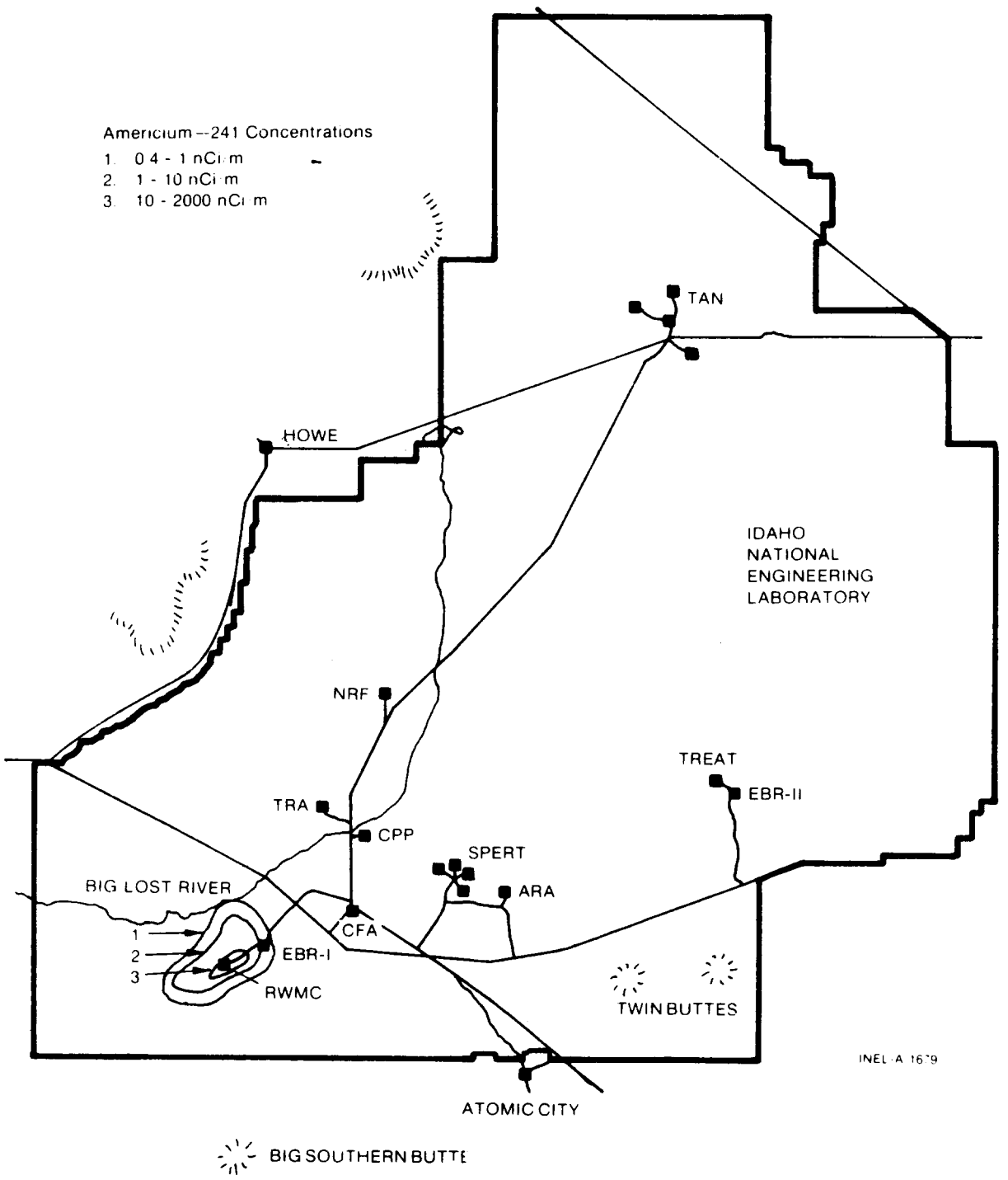


Figure III-28. Concentrations of Americium-241 in Soils Outside INEL Site Facility Perimeters.

samples having concentrations as high as 3.4 nCi/m^2, and (3) the mean fallout americium-241 concentration is 0.3 nCi/m^2 with individual samples having concentrations as high as 0.9 nCi/m^2. Plutonium-238 and plutonium-239 concentrations above fallout concentrations exist around ICPP and RWMC. Elevated americium-241 concentrations exist around RWMC. Highest soil concentrations of transuranics are localized in a drainage channel at the immediate perimeter of RWMC. Soil concentrations in areas of public access on the INEL site are background levels for plutonium-238, less than 5 nCi/m^2 for plutonium-239, and less than 1 nCi/m^2 for americium-241.

c. Impact on Biota

Radioactivity has been detected in antelope both on INEL and outside its boundaries[81,82,83]. Table III-3 gives the result of the most recent sample analyses[102]. Cesium-137 is the predominant nuclide which has been measured. Cesium-134 and cobalt-60 have been detected in some liver and muscle tissue samples. Cobalt-60 has been present only in a few samples, and then only slightly above the detection limit; cesium-134 has been detectable only in resident animals. Cesium-137 concentrations have been variable but definitely higher in animals collected onsite; the highest cesium-137 levels detected onsite were 1,520 pCi/kg of muscle and 2,660 pCi/kg of liver compared with maxima of 692 pCi/kg of muscle and 139 pCi/kg of liver in offsite animals. The doses to the antelope with the highest concentrations of activity are estimated to be <17 mrad/yr to the whole animal and <21 mrad/yr to the liver. The upper limit doses are based on the assumption that the measured concentrations were maintained continuously in the animal.

Iodine-129 has also been measured in antelope thyroid tissues. Table III-4 contains data on tissues for which the analysis has been completed. Additional thyroid tissue samples have been collected and will be analyzed when the INEL activation analysis capability is restored. The existing data (Table III-4) indicate that the iodine-129 levels in antelope have been raised by INEL activities. The thyroid dose received by antelope having the highest observed concentration of iodine-129 would be 68 mrad/yr if the observed level remained constant throughout the year.

No significant effects on either individual antelope or the resident antelope population are expected as the result of the internal irradiation received by the whole body and thyroid. The impact of INEL airborne releases on other INEL wildlife is not likely to exceed the impact on antelope. Further studies of wild species are planned to verify that the doses to them from INEL releases are small. If present release rates continue, domestic animals grazing on INEL lands may show radionuclide concentrations in tissue in excess of worldwide fallout levels (Table III-4). The doses received by these animals due to INEL operations are not expected to exceed those calculated above for antelope which graze in areas closer to the sources of radioactivity. No significant effect on the health of individual cattle or sheep or on the herds which graze on INEL lands are to be expected.

TABLE III-3

CESIUM-137 CONCENTRATIONS IN ANTELOPE TISSUES

Onsite Location[a]	Date	Cs-137 Concentration (pCi/kg) Muscle	Liver
25 mi NNE	2-20-74	110	146
0.7 mi W	4-16-74	1290	790
26 mi NE	7-7-74	76	42
17 mi NNE	7-18-74	83	44
8 mi SE	7-29-74	54	[b]
28 mi NE	8-10-74	34	[b]
22 mi NNE	8-18-74	63	44
13 mi ESE	8-22-74	51	[b]
19 mi NNE	9-4-74	83	[b]
20 mi NNE	9-29-74	71	[b]
22 mi NNE	10-26-74	49	44
0.6 mi SW	11-6-74	1520	2660
Average		290	539
1972-73 Average		350	600
Offsite Location[a]			
42 mi ENE	2-11-74	30	27
62 mi NW	6-12-74	77	139
34 mi NW	9-5-74	92	77
Average		66	81
1972-73 Average		45	55

[a] Location relative to ICPP.

[b] Sample destroyed.

TABLE III-4

IODINE-129 IN THYROIDS OF ANTELOPE ON AND NEAR THE INEL

Antelope No.	Distance and Direction from ICPP (miles)	μCi I-129/g Iodine
72-7	19 NE-N	2.2×10^{-3}[a]
72-8	0.25 N	4.7×10^{-2}[a]
72-10	4 SW	4.9×10^{-2}[a]
72-11	4 SW	6.9×10^{-2}[a]
72-12	30 N-NE	7.9×10^{-3}
73-1	56 NE	2.8×10^{-4}
73-2	23 NW	2.4×10^{-3}
73-3	4 SE	2.1×10^{-3}
73-4	0.5 E	9.6×10^{-3}

[a] Iodine-127 levels were not determined; an average iodine-127 value of 1.12×10^{3} μg/g tissue determined from other antelope thyroid samples was used in this calculation.

d. Impact on Man

The most important pathways resulting in radiation exposure of the general population around INEL involve the radioactivity released in airborne effluents. This material is dispersed as it is transported offsite, and the concentrations are reduced further by decay of the short-lived radionuclides during transport. Submersion in the plume, which contains radioactive materials and noble gases, would cause the highest doses to man; the radioactive noble gases comprised 98% of the total airborne releases in 1974. However, because deposition of these gases on foliage and soil is not significant and because they are not incorporated into the human food chain, the direct pathways are the only ones of concern.

The second largest component of the airborne waste is tritium, which may be released in several chemical forms. The most important of these forms as it affects man, is tritiated water vapor. Inhalation of tritiated water vapor is the most important pathway for inhabitants of the INEL environs; small amounts of tritiated water also will be incorporated in foods but are so diluted in the process that the dose to man is very much smaller than that due to inhalation.

As discussed in the previous section, airborne particulate materials and reactive gases are transferred to soil and vegetation.

Those nuclides which are biologically mobile, such as strontium-90, cesium-137, and iodine-129 are likely to enter organisms in man's food chain. Other nuclides, such as cerium-144, which are not incorporated in terrestrial biota, are not transferred to man in his foods but may contribute to human radiation exposure via other secondary pathways. The relative contributions of these potential exposure pathways are considered below.

(1) Noble Gases

The low concentrations of noble gases are not readily measurable at INEL boundary locations. Data on the noble gas release rates are used as input for predictive models based on meteorological measurements obtained across the Snake River Plain. The concentration isopleths are obtained and the radiation doses computed from the predicted air concentration as described in Appendix D. Table III-5 contains the whole body doses calculated for an individual who is assumed to reside continuously at the point on the southern INEL boundary where the maximum dose would be received. In addition to the whole body doses presented in Table III-5 this same individual at the southern INEL boundary would receive a skin dose of 2.7 mrem.

TABLE III-5

CALCULATED WHOLE BODY DOSES FROM RADIONUCLIDES RELEASED DURING 1974[a]

	Tritium	Argon-41	Krypton-85	Other Noble Gases	Particulates	Total
Individual at INEL boundary (mrem)	0.09	0.19	0.03	0.82	0.20	1.3
Population dose (50-mile radius) (man-rem)	0.13	0.28	0.04	1.21	0.30	2.0

[a] The whole body doses from argon, krypton, and xenon isotopes result from submersion of the recipient in the plume's penetrating radiation; the whole body dose from tritium results from inhalation of tritiated water vapor and subsequent distribution of tritium within the body; the majority of the particulate dose results from Sr-90 inhalation which is assumed to be at equilibrium within the body thus maximizing the calculated dose.

The dose to the population within a 50-mi radius of the ICPP-TRA complex was computed also. The ICPP-TRA complex was selected as the center of the 50-mi radius because almost all of the radionuclides released to the atmosphere originate at these sites. There were no

significant releases at the TAN area. EBR-II, on the eastern boundary of INEL, released minor amounts of short-lived noble gas isotopes to the atmosphere. The doses from these releases are insignificant compared with the releases from ICPP and TRA and do not affect the doses presented in Table III-5.

Most of the dose is due to short-lived noble gases; however, no correction was made for radioactive decay during transport beyond the distance to the nearest site boundary. Hence the doses shown represent the maximum postulated doses for the noble gas releases.

(2) Tritium

The doses resulting from INEL releases of tritium during 1974 were computed in a manner similar to that described for the noble gases. Inhalation of tritiated vapor leads to distribution of tritium throughout the body and internal irradiation of body tissues. The calculated maximum individual and population doses are presented in Table III-5 and are seen to be even smaller than the very low doses due to noble gas releases during the same period. The 12-yr average tritium release is about 2,700 Ci/yr; the corresponding average individual and population doses would be approximately one-half those shown in Table III-5. It is important to recognize that tritium, besides being produced at INEL, also is produced by natural processes and by nuclear weapons testing activities. The natural worldwide inventory of tritium is about 80 million Ci. Several hundred million curies of tritium have been released to the atmosphere as a result of nuclear weapons testing. The release of 33,000 Ci during the 1963 to 1974 period at INEL represents a very small addition to the world total or to the natural inventory.

(3) Iodine-129

Iodine-129 has not been detected by conventional monitoring systems in INEL gaseous releases. However, it is known that this isotope is released during fuel processing; calculations indicate that the maximum average annual release rate is about 0.1 Ci and that the maximum amount of iodine-129 in all the fuel that has been processed at ICPP is about 3 Ci. This value was used in calculating the maximum potential impact on man from INEL release of iodine-129 during 1974 operations.

Iodine-129 has been detected in antelope and deer thyroids collected on and around INEL using activation analysis techniques; these results are discussed in the section on impact on biota (Section III.B.1.c). A fraction of the local iodine-129 is the result of natural production of this isotope and of production during nuclear weapons testing. The remainder of the measured iodine-129 results from ICPP releases. Environmental iodine-129 measurements are not presently adequate to quantify the impact on man of the ICPP releases. The program of environmental measurements is continuing.

Two exposure routes are of principal interest for iodine-129 in the immediate INEL environs: inhalation, and consumption of meat from grazing animals. The maximum annual air concentration to which an offsite resident or herdsman could have been exposed was 6.0 x 10^{-4} pCi/m^3 during 1974. This air concentration would result in inhalation dose commitments of 0.022 and 0.013 mrem to thyroids of an adult and a 1-yr-old child, respectively.

Approximately 60% of INEL is open to cattle or sheep grazing. The grazing permits are administered through the Bureau of Land Management. A maximum of 63,600 sheep and 3,300 cattle are allowed to graze on INEL land each year. The sheep utilize INEL for a total of 10,000 animal unit months (AUMs) while the cattle are present on the site for 2,250 AUMs and another 900 AUMs are unclassified as to sheep or cattle usage.

The sheep grazing occurs principally in the winter and spring. After leaving INEL in the spring, the sheep usually are taken to other areas where the lambs are born, then transported to summer ranges. After 2 to 4 months on the summer ranges, some of the lambs are sold to food processing companies.

The majority of the cattle operators using INEL land are involved in either cow-calf or yearling operations. No dairy operations use INEL for grazing; most dairy cattle in local areas are maintained on stored feed. The cattle operators generally use the site in the spring, and in July transfer the cattle to summer ranges. During the fall, the operators who have yearling calves in their herds usually sell these animals to feedlots, which fatten the calves prior to their sale to food processors.

Usually, both the sheep and cattle operators using INEL land do not market their livestock immediately after the livestock are removed from INEL. However, a small percentage of these animals may be sold to food processors during the INEL grazing period. For the purpose of this and following analyses, it was assumed that the maximum dose to an individual results from animals which have grazed on INEL lands and are slaughtered immediately; this assumption maximizes the potential impact of INEL releases on the consumer.

The highest doses from consumption of meat containing iodine-129 are received by adults. An annual consumption rate of 80 kg (176 lb) of meat obtained from animals slaughtered immediately after grazing in the area of highest concentration for three months is assumed for adult consumers. During 1974, the thyroid dose which could be received by an adult with this consumption pattern was a maximum of 21 mrem.

A third potential exposure pathway for iodine-129 is consumption of contaminated milk produced by dairy cows on pasture outside the INEL boundaries. A weekly composite of Grade A milk is collected from farm areas to the north and south of Idaho Falls. Monthly samples

of Grade B milk are collected from dairies and individual farms around INEL. Grade A milk is processed for drinking; Grade B milk is used principally in cheese production. Samples of the Grade B milk were analyzed for iodine-129 from June through December 1974. Iodine-129 concentrations were all below the detection limit of 2×10^{-9} μCi/ml. If the iodine-129 concentration had been maintained in equilibrium at the detection limit of 2×10^{-9} μCi/ml, a 1-yr-old child who consumed milk from a family cow could have received an undetected thyroid dose of 9 mrem during 1974.

(4) Iodine-131

The exposure routes of greatest concern for the relatively short-lived isotope iodine-131 are by inhalation and by consumption of milk produced by dairy cows on pasture outside the boundaries of INEL. The total release of iodine-131 during 1974 was 0.11 Ci; the maximum inhalation doses which could have been received in 1974 are 0.014 and 0.007 mrem to the thyroids of a 1-yr-old child and of an adult, respectively. These doses would be reached only if an individual were located at the point of maximum concentration throughout the period of the iodine-131 release.

The results of the milk sampling program during 1974 are shown in Table III-6. Iodine-131 was detected in 11 of 153 collected milk samples. Ten of these positive results were obtained during the month of July and are attributed to fallout from a foreign atmospheric test conducted on June 17; the fallout was estimated to have arrived at INEL about June 28. The other positive result of 1.5×10^{-9} μCi/ml may have been related to iodine-131 releases from INEL during the last week in May. In all cases, the detected concentrations were less than 4×10^{-9} μCi/ml; the 1974 average concentrations may have been as high as 8×10^{-9} μCi/ml because for the first three months the iodine-131 detection limit was 2×10^{-8} μCi/ml or greater, depending on the time between sample collection and analysis.

If the iodine-131 concentration had, in some manner, been maintained at the detection limit throughout the year, a 1-yr-old child who consumed milk from a family cow could have received an undetected dose of 50 mrem. However, virtually all the 0.11 Ci of iodine-131 release from INEL occurred in May, when the more sensitive milk monitoring technique was employed; therefore, the maximum dose attributable to INEL releases is much lower. A 1-yr-old child consuming milk from a family cow could have received a dose of at most 2 mrem during May and early June 1974, following INEL iodine-131 releases.

(5) Particulate Radioactivity -- General

The onsite and offsite concentrations of airborne radioactive particulates are monitored continually by means of a network of sampling stations (Figure II-72). Onsite air samples are collected at locations close to the release points, and therefore are expected to have the highest concentrations. Control samples are collected at Idaho Falls, Blackfoot, and Pocatello; these locations are considered

TABLE III-6

CONCENTRATIONS OF MANMADE RADIONUCLIDES IN MILK FOR 1974

	Concentration (10^{-9} μCi/ml)[a]		
	I-131		Sr-90
Detection Limit	0.6[b]		2
Concentration Guide[c]	100		200
Sample Location	I-131 Maximum	I-131 Average[d]	Sr-90 Maximum
Idaho Falls	3.9 ± 1.3	0.2 - 6	9 ± 2
Minidoka	1.9 ± 0.9	0.2 - 7	BDL[e]
Dietrich	< 26[b]	0 - 9	3 ± 2
Carey	3.6 ± 1.0	0.3 - 8	BDL
Reno Ranch	< 30[b]	0 - 8	BDL
Mud Lake	< 24[b]	0 - 5	5 ± 2
Howe	2.3 ± 1.0	0.2 - 6	8 ± 2
Arco	3.3 ± 1.5	0.3 - 8	BDL
Firth Route	2.4 ± 0.9	0.2 - 7	13 ± 4
Riverside Route	1.7 ± 0.9	0.1 - 7	BDL

[a] Analytical results ± 2σ decay corrected to time of collection. All the minimum concentrations were BDL.

[b] Detection limit does not include correction for decay from the time of sample collection to time of analysis. The detection limit for samples collected in January, February, and March was 2.0×10^{-8} μCi/ml, not considering decay.

[c] I-131 and Sr-90 intake guides for milk were established by the Federal Radiation Council.

[d] The average concentration is given as a range because some analyses were BDL. The lower range value is calculated by assuming all BDL values equal to zero, the higher value by assuming all BDL values equal to the detection limit.

[e] BDL - Below Detection Limit

sufficiently removed from the northeast-southwest flow, which transports INEL airborne effluents, to deduce that any radioactivity detected is due to natural background or to sources other than INEL operations. Levels of radioactivity in air samples from boundary community locations (Arco, Monteview, Reno Ranch, Atomic City, Craters of the Moon, Howe, and Mud Lake) are compared with levels in the control areas. If specific radionuclide concentrations are (statistically) significantly higher, the net amount above background is assumed to be caused by INEL operations. The net concentrations of radioactivity can be compared with the concentration guides (CGs) for inhalation set forth in AECM(ERDA) Chapter 0524[7].

Concentrations of beta-emitting radioactivity on airborne particulate material during 1974 are shown in Table III-7. As can be seen from

TABLE III-7

PARTICULATE BETA ACTIVITY IN AIR (1974)

Location	Concentration (10^{-15} µCi/ml)[a] Minimum Observed	Maximum Observed	Annual[b] Average	AECM (ERDA) 0524[c] Standard
Distant Stations				
Idaho Falls	73	810	280 ± 390	1,000
Blackfoot	88	760	310 ± 390	1,000
Pocatello	67	790	300 ± 390	1,000
Boundary Stations				
Arco	84	650	250 ± 330	1,000
Atomic City	110	930	320 ± 410	1,000
Craters of the Moon	82	970	320 ± 250	1,000
Howe	94	720	300 ± 370	1,000
Monteview	46	650	260 ± 320	1,000
Mud Lake	77	880	310 ± 410	1,000
Reno Ranch	63	890	310 ± 410	1,000

[a] The minimum detection limit is approximately 5 x 10^{-15} µCi/ml gross beta for a weekly sample collected at the rate of one SCFM.

[b] Average and two sample standard deviations calculated from weekly data. Sample standard deviations are large because of seasonal variations in fallout radioactivity.

[c] NRC or ERDA standard applicable to concentrations of gross beta activity in excess of concentrations due to natural causes and fallout. Standard listed assumes Ac-227 not present.

the tabled data, and more clearly from Figure III-29, there are substantial time variations in the particulate beta activity concentrations. The monthly variations are related principally to the transport of weapons fallout from the stratosphere to the troposphere each spring. Contributions from specific weapons tests can be readily observed during winter months; December 1970 and January 1972 are good examples. The marked increase in concentrations during 1974 is related to the injection of new fallout debris into the atmosphere from nuclear tests in June 1973 and June 1974. The presence of the short-lived isotopes cerium-141 and ruthenium-103 is indicative of the June 1974 atmosphere testing.

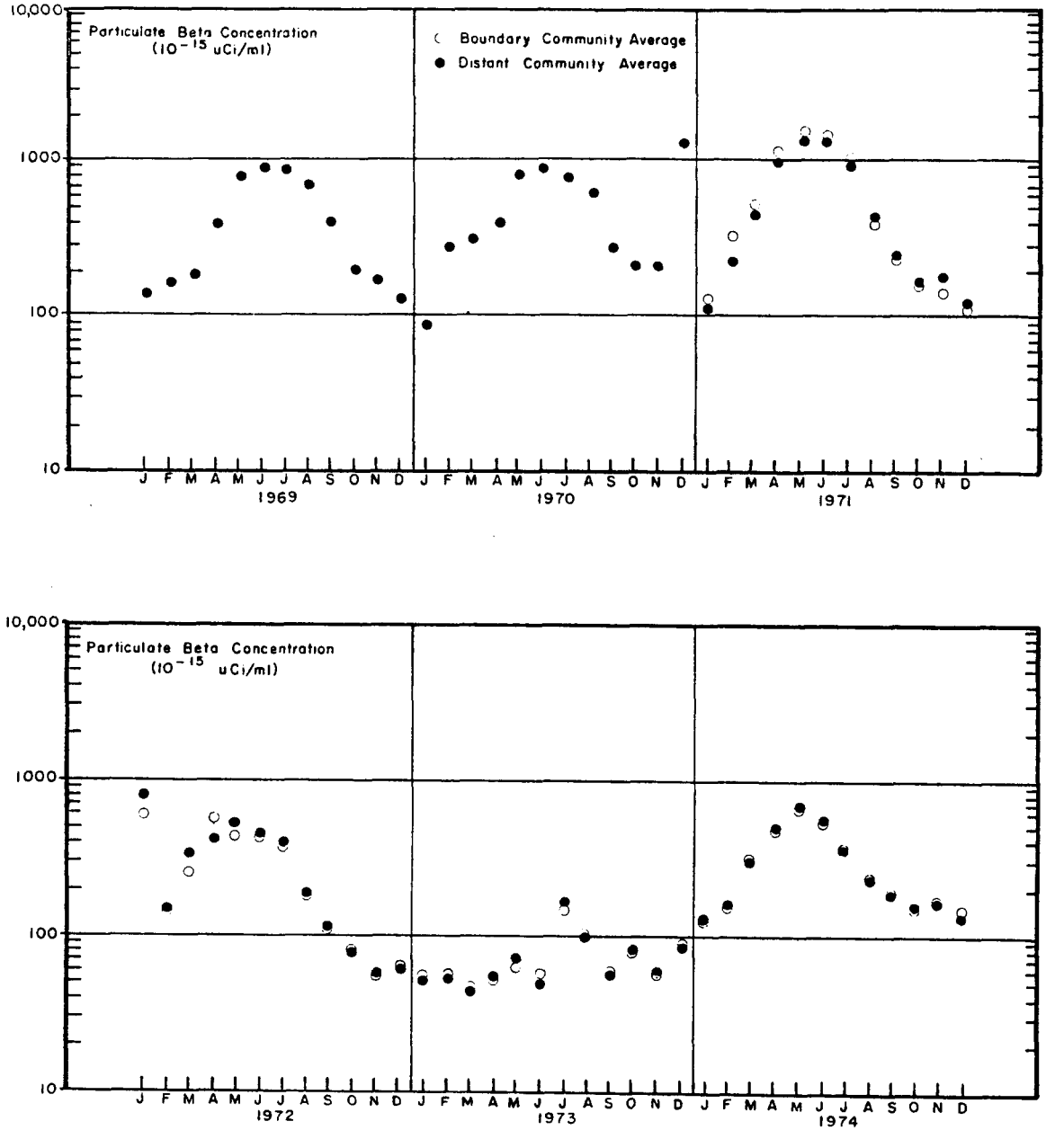


Figure III-29. Particulate Beta Concentrations in Air (1969 to 1974).

Quarterly composites of the particulate filters from the sampling system are analyzed using gamma spectrometry and for specific alpha- and beta-emitting nuclides at four boundary and two distant sampling stations. All quarterly composites were analyzed in 1974 by gamma spectrometry. Since strontium and plutonium analyses cannot be performed on the same sample using existing procedures, these analyses were performed on alternate quarterly composites and were alternated between stations in the same downwind direction from ICPP. The results of the specific radionuclide analyses for one distant and two boundary sampling stations are given in Table III-8, along with the corresponding detection limits and concentration guides.

Of these detected, the radionuclides with the highest concentrations, beryllium-7, is a naturally occurring radionuclide formed by the interaction of cosmic rays with oxygen and nitrogen in the upper atmosphere. The other radionuclides detected were fission products, plutonium-238, and plutonium-239. These nuclides must be due either to worldwide fallout or to INEL operations. No differences in minimum, maximum, or average concentrations between the distant (background) stations and the boundary stations were observed, indicating that the air concentrations derived from the small amounts of particulate radioactivity released to the atmosphere from INEL operations are obscured by concentrations of worldwide fallout. Maximum concentrations for all nuclides occurred during the second quarter and minimum concentrations occurred in the first and fourth quarters of 1974. These maxima and minima correlate with those observed for particulate beta concentrations. The ratio of the maximum to the minimum concentrations of the naturally occurring nuclide beryllium-7 ranged from approximately 1.5 to 3. For other nuclides, this ratio was generally higher, ranging from 4 to 8. This difference may reflect differences in the distribution of manmade radionuclides and beryllium-7 in the upper atmosphere or the direct tropospheric injection of manmade radioactivity.

Major fractions of INEL releases of particulate radionuclides occurred during the first and fourth quarters. Approximately 60% of the cesium-137, 70% of the ruthenium-106, and 30% of the strontium-90 were released during the first quarter. About 75% of the antimony-125, released as a gas but at least partially attached to atmospheric particulates in the environment, was released during the fourth quarter. During these quarterly periods, when the fallout component was a minimum, the INEL contribution to airborne radioactivity at boundary locations could not be detected above worldwide fallout levels.

Average concentrations of plutonium-238 and plutonium-239 are less than 0.1% of the corresponding concentration guides for inhalation, and the doses due to inhalation of these nuclides are correspondingly low. The maximum pulmonary region annual dose resulting from inhalation of plutonium-238 and plutonium-239 in air at concentrations measured during 1974 was 1 mrem. This dose is mainly, if not completely, attributable to worldwide fallout.

TABLE III-8

SPECIFIC RADIONUCLIDE ACTIVITY IN AIR (1974)

Location	Isotope	Concentration (10^{-15} µCi/ml)[a] Detection Limit	Minimum Observed	Maximum Observed	Annual Average	Concentration Guide AECM (ERDA) 0524
Distant Station						
Idaho Falls	Be-7	10	170 ± 40	300 ± 40	220 ± 110	2×10^8
	Mn-54	2	BDL[b]	BDL	-	1×10^6
	Sr-90	0.6	1.1 ± 0.6	2.6 ± 1.0	1.9[c]	3×10^4
	Zr-95[d]	6	BDL	59 ± 12	23 - 29	4×10^6
	Ru-103	5	BDL	9 ± 6	4 - 12	2×10^7
	Ru-106	11	BDL	70 ± 20	24 ± 40	3×10^6
	Sb-125	5	BDL	BDL	BDL	2×10^7
	Cs-137	3	2.5 ± 1.8	14 ± 4	6 - 7	1×10^7
	Ce-141	3	11 ± 8	14 ± 12	10 ± 27	2×10^7
	Ce-144	6	27 ± 10	140 ± 7	65 ± 100	3×10^5
	Pu-238	0.002	BDL	BDL	-[c]	70
	Pu-239	0.002	0.018 ± 0.008	0.110 ± 0.014	0.064[c]	60
Boundary Stations						
Arco	Be-7	10	160 ± 40	310 ± 60	240 ± 120	2×10^8
	Mn-54	2	BDL	2.8 ± 1.2	0.6 - 2.5	1×10^6
	Sr-90	0.6	1.4 ± 0.6	1.6 ± 0.8	1.5[c]	3×10^4
	Zr-95[d]	6	13 ± 6	40 ± 8	25 ± 22	4×10^6
	Ru-103	5	BDL	9 ± 6	4 - 13	2×10^7
	Ru-106	11	BDL	60 ± 10	24 - 37	3×10^6
	Sb-125	5	BDL	BDL	BDL	2×10^7
	Cs-137	3	BDL	12 ± 2	5 - 6	1×10^7
	Ce-141	3	BDL	7 ± 4	4 - 6	2×10^7
	Ce-144	6	18 ± 6	120 ± 12	58 ± 87	3×10^5
	Pu-238	0.002	BDL	BDL	-[c]	70
	Pu-239	0.002	0.030 ± 0.008	0.100 ± 0.010	0.065[c]	60
Mud Lake	Be-7	10	110 ± 40	350 ± 80	225 ± 210	2×10^8
	Mn-54	2	BDL	6 ± 2	1.5 - 2.9	1×10^6
	Sr-90	0.6	1.1 ± 0.6	2.5 ± 0.8	1.8[c]	3×10^4
	Zr-95[d]	6	10 ± 6	53 ± 12	23 ± 40	4×10^6
	Ru-103	5	BDL	13 ± 4	7 - 9	2×10^7
	Ru-106	11	BDL	80 ± 40	37 - 61	3×10^6
	Sb-125	5	BDL	9 ± 6	5 - 6	2×10^7
	Cs-137	3	2.3 ± 1.6	12 ± 2	5 ± 6	1×10^7
	Ce-141	3	BDL	19 ± 6	8 - 10	2×10^7
	Ce-144	6	10 ± 10	144 ± 16	57 ± 120	3×10^5
	Pu-238	0.002	BDL	BDL	-[c]	70
	Pu-239	0.002	0.027 ± 0.008	0.100 ± 0.010	0.064[c]	60

[a] Analytical results ± 2σ, decay corrected to midpoint of sampling period. Average and two sample standard deviations reported if radionuclide detected in all quarterly composites, otherwise the possible range of the average is reported. The lower range value is calculated by assuming all BDL values equal to zero, the higher value by assuming all BDL values equal to the detection limit.

[b] BDL - Below Detection Limit.

[c] Only two samples analyzed. Therefore, a meaningful two sample standard deviation could not be obtained.

[d] Data decay corrected to midpoint of sampling period. Nb-95 was detected whenever its parent, Zr-95, was detected.

Manmade alpha-emitting radionuclides such as plutonium-239 are strongly discriminated against as they pass through the gastrointestinal tracts of man or foraging animals, and only a very small fraction is transferred to the blood. Nearly all the ingested activity is excreted in the feces. These actinides also are relatively immobile in soil and are not absorbed to any large degree in plant roots. For these reasons, exposure pathways other than inhalation are not significant for evaluations of the dose to man.

The measured concentrations of strontium-90 and the gamma-emitting radionuclides are very small fractions of the appropriate concentration guides for inhalation of the various isotopes. The doses from inhalation of these isotopes during 1974 were correspondingly low and attributable principally to worldwide fallout from testing of nuclear weapons. However, specific radionuclides associated with INEL activities may produce doses to man via indirect exposure pathways shown in Figure III-1; these are considered below.

(6) Strontium-90

The principal pathway besides inhalation for exposure to man from strontium-90 released to the atmosphere is the transfer of strontium-90 to the milk of cows feeding on pastures where strontium-90 has been deposited. The relative magnitudes of known strontium-90 deposition as the result of INEL releases and worldwide fallout were considered in the discussion of impact on land (Section III.B.1.b); fallout strontium-90 is by far the greatest contributor to the strontium-90 in soil and vegetation in dairy farm areas around INEL. As shown in Table III-6, strontium-90 was detected in milk samples at levels which are less than 7% of the radiation concentration guide value. Consumption of 1 liter/day of milk having this strontium-90 concentration throughout the year would produce a dose to the bone marrow of 14 mrem/yr.

Because grain is a major source of man's calcium and because strontium simulates calcium metabolically, wheat samples are analyzed to determine the uptake of strontium-90 from soil by grain. Since an average of 90% of the strontium-90 is contained in the hulls, only about 10% of the activity would enter food products produced from the processed wheat. As is the case with the strontium-90 found in milk, the strontium-90 measured in wheat is due to worldwide fallout. The data for 1974 and the 6-yr averages are presented in Table III-9. The concentrations vary from year to year at all locations; there are no statistically significant differences among the sampling locations.

Vegetation contaminated with strontium-90, principally from fallout, is consumed by animals grazing on and around INEL. Nearly all (99%) of the strontium-90 in the animals is located in the bone; consumption of the meat of grazing animals is not a significant route for transfer of strontium-90 to man.

TABLE III-9

STRONTIUM-90 IN WHEAT SAMPLES

Sampling Location	Strontium-90 Concentration (pCi/g) 1974[a]	6-Year Average[b]
American Falls	0.018 ± .006	0.015 ± .016
Arco	0.011 ± .004	0.011 ± .012
Blackfoot	0.009 ± .004	0.015 ± .008
Carey	0.009 ± .004	0.013 ± .008
Dietrich	0.017 ± .004	0.011 ± .008
Idaho Falls	0.014 ± .004	0.015 ± .010
Minidoka	0.014 ± .004	0.013 ± .006
Monteview	0.012 ± .004	0.013 ± .012

[a] Analytical results ± 2σ.

[b] Mean value ± two sample standard deviations.

(7) Cesium-137

In addition to inhalation, there are three potential exposure pathways of concern for cesium-137 released to the atmosphere: consumption of contaminated milk, external radiation from deposited material, and ingestion of contaminated meat from grazing animals.

Both Grade A and Grade B milk samples were analyzed for cesium-137 using gamma spectrometry. No cesium-137 was measured above the detection limit of 3.0×10^{-8} μCi/ml. If the cesium-137 concentration had been raised to 3.0×10^{-8} μCi/ml as the result of INEL activities, the maximum undetected dose to a child consuming milk produced offsite would have been 0.66 mrem to the whole body.

If the 1974 INEL release rate persists for the next ∿90 yr, the maximum concentration of cesium-137 in soil will be 300 nCi/m^2 as the result of INEL activities. The external radiation exposure resulting from this accumulation of cesium-137 depends upon its distribution in the soil. Assuming the relaxation length of 2 cm (0.8 in.) presently observed for cesium-137 is indicative of future conditions, the maximum total exposure rate at 3 ft above the surface will be 1.50 μR/hr. The genetically significant dose (considering the effects of body screening and dwelling shielding) to a person who spends the full year at the point of maximum soil concentration 90 yr hence will be 4.0 mrem/yr.

If animals are permitted to graze in the area of maximum cesium-137 buildup, the lean meat of the animals will contain cesium-137. Although all consumers of meat would receive some dose from consumption of the meat, the large dose would be received by adults. The equilibrium concentration of cesium-137 in the meat in the area of maximum annual deposition would be 135 pCi/kg (61 pCi/lb); an adult consuming 80 kg/yr (176 lb/yr) of meat produced in that area would receive an annual whole body dose of 0.77 mrem as the result of the cumulative releases of cesium-137.

During 1974 and early 1975, six sheep from bands grazing by permit on INEL and adjacent lands were purchased to obtain samples of edible tissue. Four sheep grazing on native vegetation at locations distant from INEL were purchased for the same purpose. Measured connentrations of cesium-137 are shown in Table III-10. The high concentrations of cesium-137 in tissues of the animal collected on August 30 are believed to be the result of fallout from a June 17 foreign atmospheric test. Neither the higher concentrations of cesium-137 in muscle of the INEL area animals nor the higher concentration of cesium-137 in livers of the distant location animals is statistically significant at the $\alpha = 0.05$ level. Additional sampling of grazing animals is planned. The average dose to individuals consuming meat from animals grazing on and near INEL is not significantly greater than that to persons consuming meat produced in other locations; annual consumption of 80 kg (176 lb) would result in an annual dose of 0.38 mrem to the consumer. The potential dose from meat obtained soon after atmospheric nuclear weapons testing may be ten times greater.

Cesium-137 has been detected in the tissue of antelope, which are the predominant big game animals on INEL land. In addition to a resident population on the station, a considerable number of antelope pass through INEL when migrating between higher summer ranges to the north and desert winter ranges to the south. Although hunting is not permitted on INEL land, it is possible that animals eating contaminated forage onsite could be killed offsite by hunters. If a hunter had killed the antelope with the highest observed cesium-137 concentration of 1,520 pCi/kg (690 pCi/lb) and had consumed all the muscle (50 lb) and the liver (2.2 lb) himself, he would have received a dose of 2.7 mrem to the whole body. Measured concentrations of cesium-137 in antelope muscle collected offsite have never exceeded 92 pCi/kg (42 pCi/lb); hunters killing animals with that concentration and consuming all the meat themselves would receive annual whole body doses of 0.16 mrem. The latter circumstance is much more likely, since the fall migration of antelope across INEL does not occur until after the hunting season. Cesium-137 is eliminated from antelope with a half-life of about 14 days; therefore, animals which passed through INEL in the spring will have eliminated nearly all the cesium-137 ingested there by the time the hunting season opens in the early fall.

(8) Ruthenium-106

External radiation from deposited material is the only exposure pathway of importance for ruthenium besides inhalation. The fact

TABLE III-10

CESIUM-137 CONCENTRATIONS IN SHEEP TISSUE

On-Site Location[a]	Date	Cesium-137 Concentration (pCi/kg) Muscle	Liver
7 mi SE	5-22-74	72	50
7 mi SE	5-22-74	39	51
13 mi SW	6-21-74	83	45
19 mi SE	1-14-75[b]	76	70
25 mi NE	1-21-75[b]	96	81
25 mi NE	1-21-75[b]	75	62
Average		74	60
Off-Site Location			
Dubois, Idaho	6-20-74	44	57
Humphrey, Idaho	8-30-74[c]	599	286
Rupert, Idaho	1-28-75[b]	43	71
Rupert, Idaho	1-28-75[b]	68	99
Average		52	76

[a] Location relative to ICPP.

[b] All animals collected in 1-75 were receiving supplementary feed, either corn or hay; either source could contain cesium-137 from worldwide fallout.

[c] Not included in average comparison.

that less than 5% of the ingested ruthenium will enter the bloodstream prevents the consumption of meat of grazing animals from becoming an important pathway. As discussed previously, the ruthenium-106 level in soil could reach 80 nCi/m^2 at the point of maximum deposition. This accumulation of material would produce an annual genetically significant dose of 0.36 mrem to an individual who occupied the area of highest contamination continuously.

(9) Cerium-144

The fractional absorption of cerium-144 in the gastrointestinal tract is extremely small, less than 0.1%. External irradiation from deposited material is the only indirect pathway of concern.

The maximum concentration of cerium-144 is projected to be 20 nCi/m^2. The maximum annual genetically significant dose which could be received during continuous occupancy would be 0.022 mrem.

e. Conclusion

The dose to the general population results primarily from the releases of noble gases and tritium to the atmosphere. The estimated 50-mi-radius population dose of 2.0 man-rem is a small fraction (0.02%) of the population dose from background radiation exposure. Potential doses to a small number of individuals from specific radionuclides are within the range of variability of the annual whole body background dose (150 $\pm$ 15 mrem). A thyroid dose of at most 11 mrem might have been received by an infant consuming iodine-129 and iodine-131 in milk from a family cow. An individual consuming 80 kg (176 lb) of meat from animals grazing at the point of highest concentration could have received a thyroid dose of about 21 mrem from iodine-129 and might receive a whole body dose of at most 4 mrem from consumption of wild and domestic animal meat. External radiation from deposited material may produce doses of at most 5 mrem to individuals, such as herdsmen, who might spend a significant fraction of the year in the area of projected maximum soil contamination. (These doses are summarized in Section I, Table I-2).

2. Nonradioactive Airborne Wastes Discharged to the Atmosphere[a]

a. Sources and Environmental Impacts

Nonradiological airborne wastes originate from three primary sources at INEL: combustion of fuel oils for heating, calcination or solidification of liquid wastes, and motor vehicle exhaust. Minor inconsequential releases occur as a result of evaporation of organic solvents at shops and vapor drift from cooling towers. The major contaminants are the common industrial oxides of nitrogen, sulfur, and carbon.

The consumption of fuel oil during 1974 and the calculated amount of waste produced is shown in Table III-11.

(1) Oxides of Nitrogen

Nitrogen oxides are produced during the calcination process by the thermal decomposition of nitric acid and metal nitrates. An average of 2,000 to 4,000 lb of nitrogen oxides is discharged each day at ICPP. Carbon dioxide and particulate matter also are discharged. The facility presently being used for this process has been in use since 1963, and plans are being developed to construct a replacement. Table III-12 shows the release from the present plant and that anticipated from the new plant.

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[a] See Appendix E (Table E-5 and Section 2) for 1975-76 nonradioactive airborne releases and its environmental impact.

TABLE III-11

CONSUMPTION OF FUEL OIL AND WASTE PRODUCED (1974)

Area	Consumption (gal) and Grade				Waste Products (lb)	
	No. 2	No. 5	Kerosene	Diesel	Sulfur Dioxide	Particulates
ANL	770,330	--	--	--	36,755	3,460
ARA	6,980	27,781	--	--	7,012	1,153
CFA	183,107	407,140	--	--	104,910	16,896
CPP	1,888,200	--	51,563	--	50,200	--
NRF	--	1,609,010	--	--	523,360	28,802
PBF	9,111	12,264	--	--	3,256	509
TAN	--	845,470	--	700	207,767	35,089
TRA	--	1,154,760	--	391,450	294,152	47,923
Total	2,857,728	4,056,425	51,563	392,150	1,227,412	133,832

TABLE III-12

WASTE RELEASE FROM CALCINING PLANTS TO ATMOSPHERE

Contaminant	Release (lb/day)	
	WCF[a]	WCF Replacement[b]
Nitrogen oxide	3,800	4,000
Carbon monoxide	2,000	2,500
Particulates	0.003	0.004

[a] WCF processing 2,100 gal/day for 150 days/yr.

[b] WCF Replacement processing 3,000 gal/day for 250 days/yr.

About 100 diesel powered buses are used to transport workers to INEL. In addition, there are approximately 600 gasoline powered automobiles and trucks. These vehicles consume about 1 million gallons of diesel fuel and 750,000 gallons of gasoline each year. A order-of-magnitude estimate of the amount of waste products released

per year from this source is shown in Table III-13. The 320,000 lb/yr of nitrogen oxides would be about 800 lb/day, as compared with 2,000 or 4,000 lb/day from the calcining process.

TABLE III-13

FUEL AND WASTE FROM VEHICLE ENGINES USED AT INEL PER YEAR
(0.75×10^6 gal-Gasoline) (1×10^6 gal-Diesel Oil)

Contaminant	Gasoline Emissions (lb)	Diesel Emissions (lb)
Aldehydes	3,000	10,000
Carbon monoxide	1,740,000	60,000
Hydrocarbons	150,000	140,000
Nitrogen oxides	100,000	220,000
Sulfur oxides	7,000	40,000
Acids	3,000	30,000
Particulates	8,000	100,000

The release of contaminants to the atmosphere from other miscellaneous sources is small. An order-of-magnitude estimate is shown in Table III-14.

TABLE III-14

MISCELLANEOUS EVAPORATION WASTE TO ATMOSPHERE

Source	Contaminant	Amount
Gasoline	Volatiles	68,000 gal/yr
Solvents	Volatiles	2,500 gal/yr
Incinerators	Particulate and gases	None
Cooling towers	Dissolved solids	Not measured

The direct effects on the environment are confined to the biosphere, (i.e., the air, vegetation, and land surface) and indirectly to the animal and human life.

A visible brown nitrogen dioxide haze is released from the ICPP stack as a result of the calcine operation. It combines with water to form nitric acid that, in turn, can react with ammonia or particles in the air to form nitrate salts, which ultimately fall or are washed out with rain. If it is assumed that 4,000 lb

of nitrogen dioxide are released per day for 200 days, the total release would be 800,000 lb, of which 30% (or 240,000 lb) would be elemental nitrogen. If this were deposited uniformly over the 572,000 acres of INEL, the deposition would be about 2.5 lb/acre or about the same as might be expected from natural causes. The desert soils on the Snake River Plain are inherently low in nitrogen and would not support intensive cropping without deliberate applications of nitrogen fertilizer at rates of 50 to 150 lb of nitrogen/acre. For good crop yields, soil usually contains 3,000 to 5,000 lb of nitrogen/acre within a 6-in. depth.

Nitrogen dioxide pollution has also been monitored at five INEL locations. The highest single observed concentration has been 4.3 $\mu g/m^3$ compared with a standard of 100 $\mu g/m^3$.

Nitrogen oxides are irritating to body tissues at low concentrations. The main concern as an air pollutant is its participation in photochemical reactions with other pollutants to form "smog" and free oxygen or ozone. EPA has defined a limit of 100 $\mu g/m^3$[42]. In comparison, the estimated concentrations at the nearest INEL boundary resulting from calcining operations are less than 1 $\mu g/m^3$ as shown in Table III-15.

TABLE III-15

ESTIMATED CONCENTRATIONS OF CONTAMINANTS AT THE INEL BOUNDARY AS A RESULT OF WASTE CALCINATION

Contaminant	Concentration ($\mu g/m^3$)[a] WCF	NWCF[b]
Nitrogen oxides	0.26	0.54
Carbon monoxide	0.2	0.35
Particulates	2.5×10^{-10}	6×10^{-10}

[a] WCF -- Processing 2,100 gal/day for 150 days/yr.
NWCF -- Processing 3,000 gal/day for 250 days/yr.

[b] NWCF -- New Waste Calciner Facility

(2) Oxides of Sulfur

Sulfur can exist in the air in several compound forms: hydrogen sulfide, salts, oxides, and sulfuric acid. Ultimately all forms are oxidized to sulfur trioxide which, when dissolved in water, forms

sulfuric acid. The acid and salts are removed by rain and snowfall and to a lesser extent by gravity within a period of 5 to 14 days. During the time that sulfur trioxide remains in the air it can, in sufficient concentrations (1,000 $\mu g/m^3$), be an irritant to people and, if precipitated in sufficient concentration, can detrimentally affect plant cover and damage property. Based on measurements at five onsite sampling locations, detrimental concentrations do not occur at INEL, as dispersion results to the extent that sulfur trioxide is below the detection limit of 7.5 $\mu g/m^3$. Any fallout, or washout, would be neutralized by the alkaline soil. It therefore seems reasonable to infer that the impact of the sulfur discharge is inconsequential.

(3) Oxides of Carbon

Carbon monoxide becomes toxic at a level of about 120,000 $\mu g/m^3$. The air quality standard is 10,000 $\mu g/m^3$[42]. In comparison, the concentration at the INEL boundary resulting from the discharge from the calcining process is 0.2 to 0.35 $\mu g/m^3$. The ultimate disposition of this gas has not been determined. It is chemically inert and apparently reacts with no other constituent of polluted air, yet seemingly it does not accumulate -- at least at a rate which can be measured conclusively. Perhaps the most likely disposition of carbon monoxide is that it is converted to carbon dioxide, which then becomes a part of the natural carbon cycle. Most vehicles have been equipped with emission control equipment in an effort to reduce emissions to the lowest practical minimum. Traffic is not concentrated, and releases from this source could not reach a toxic level.

Discharge of carbonaceous particulate matter to the atmosphere is very small. Burning of solid waste is limited by special permits, and stack emissions are seldom visible except during startup of burners. Airborne particulate matter was routinely monitored at several onsite, boundary community, and distant locations prior to 1973. However, the sampling data always showed particulate concentrations at INEL considerably below standards so the routine sampling program was discontinued in 1973. The last collected data during 1972 showed that the average onsite concentration of airborne particulate matter was 19 $\mu g/m^3$ compared with an offsite average of 51 $\mu g/m^3$, as compared with the standard of 60 $\mu g/m^3$ (42 CFR Part 410)[42]. Table III-16 shows the concentrations at INEL locations as compared with offsite locations. The higher offsite concentrations are probably due to urban heating, agricultural activities, and light industry.

(4) Other Discharges

Another discharge of minor consequence is the water released to the atmosphere from evaporative cooling towers, spray ponds, and disposal ponds through evaporation. The effects of water vapor released, mainly from cooling towers during operation, have not been significant in past operations and are not projected to become

TABLE III-16

AIRBORNE PARTICULATE MATTER CONCENTRATION FOR 1972

Location	Maximum Weekly Average Concentration ($\mu g/m^3$)	1972 Average Concentration ($\mu g/m^3$)
Distant Stations		
Blackfoot	178	44
Idaho Falls, ERDA-ID Headquarters	98	50
Pocatello Fire Station	155	53
Pocatello Sewage Plant	262	119
Boundary Stations		
Arco	175	63
Butte City	68	23
Howe	145	42
Monteview	256	47
Mud Lake	214	50
Reno Ranch	43	15
Onsite Stations		
ARA-II	49	19
CFA	29	14
EBR-I	28	13
EBR-II	109	30
NRF	50	20
SPERT	29	13
TAN	69	17
TRA	99	26

a problem in the future. Experience at INEL has shown that the visible plumes dissipate within a few hundred feet of the tower, even under unfavorable meteorological conditions. The local climate is not affected, and no significant fogging or icing of nearby roads has been experienced or is anticipated.

b. Conclusion

When compared with the amount of chemical compounds which occur naturally, the air quality standards, and the amounts contributed by other industrial processes, the effect on the biosphere of nonradiologically contaminated airborne waste discharged at INEL is inconsequential.

3. Radioactive Liquids Discharged to the Lithosphere[a]

a. Sources of Discharges

The ultimate objective in radiological waste management operations is to exclude all radiological wastes from the human environment until the radioactivity is eliminated by radioactive decay. Accomplishment of this objective entails concentration, or reduction of volume, and storage of the residuum. The chemical and physical processes and systems have been described in Section II. These processes result in two solution fractions; one in which the concentration of radionuclides has been increased to an intermediate level and the other with a low concentration considered acceptable for discharge.

ERDA policy requires that liquid wastes classified as intermediately contaminated (i.e., other than that which can be economically retained and confined and which cannot be safely discharged) be converted into two fractions: one consisting of low-level concentrations which can be safely discharged, and the other high-level concentrations which can be confined.

Wastes in the low-level category are defined as those liquids which can be discharged to the environment with assurance that persons will not be exposed to concentrations in excess of prescribed limits. As previously noted, these solutions result from reactor operations, waste processing, and associated ancillary operations such as a laundry, laboratories, and test facilities.

Highly contaminated liquids cannot be discharged to the envirnoment, and it is ERDA's policy to convert these liquids to a physical and chemical form suitable for confinement in long-term storage facilities. The storage facilities provide isolation from the environment with minimal reliance on perpetual maintenance and surveillance, and they must be able to withstand credible geologic, seismic, and other naturally occurring events[2]. Toward this goal the stored liquids are converted to a dry solid by a calcining process. The solids are then contained in tanks and/or bins enclosed within concrete vaults. These structures are designed to withstand or minimize the effects of credible natural disasters.

b. Discharge History

Table III-17 is a record of the liquid waste discharged from the various plant establishments during the past 23 yr[8]. Approximately 96% of the volume and 98% of the radioactivity has been discharged at two locations: TRA and ICPP. The curie amounts are based on the assay of effluent streams at the time of release. These

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[a] See Appendix E (Table E-2 and Section 2) for 1975-76 radioactive liquid waste releases and its environmental impact.